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HERDER'S PSYCHOLOGY

FROM Descartes to Kant, Rationalism was the dominant type of philosophy. Reason, defined as the faculty of ratiocinative reflection, producing "clear and distinct" ideas, was the supreme arbiter of reality. It was conceived as the ultimate moulder of all experience, transforming, through "a priori" action of its synthetic "spontaneity," the data of perception into the primary objects of knowledge. Being thus the absolutely first condition, antecedent to every particular act, of cognition, it could not itself be object of knowledge, but must be forever beyond the reach of the individual mind. It must be assumed, or "postulated," as the transcendental, absolute and universal Knower, himself not knowable, the mind of God. The individual human mind could be only a fragmentary and imperfect phenomenon of this Knower. Only by obeying the laws of "clear and distinct" reflection, by following the laws of logic, supposed to be inherent in the transcendental mind and therefore absolute, could the human, or "empirical," reason adjust itself, within the narrow limits of its native capacity, to the regulative guidance of the true reason.

Individuality, since it involves a conception of spontaneity, the essence of which is an irreducible singularity of motive, a specific exemption from universal causation, cannot be, in a rationalistic psychology, a primary entity. It lacks fundamental autonomy. It receives the character of a radical insurrection against truth, an aggression upon

absolute virtue, a perversion of reasonable being. Individualism, to strict rationalism, is the sin of Lucifer.

The historical reaction against rationalism, the beginning of which roughly coincided with the beginning of the eighteenth century, gathering headway and volume with constant acceleration, took a bewildering variety, richness, and complexity of forms. It included Locke's theory of the primacy of the data of the senses as the source of the contents of the mind; the later developments of sensualism, or sense-ism, and associationism; the psychological conclusions drawn by the physiologists of the seventeenth and eighteenth centuries, and the similar associationistic theories of Hartley and Priestly, according to which the mind is dependent on the mechanism of the nerves; the theory of sensibilism, or "Gefühl," according to which "inner felling" or immediate "inward" perception, holds the primary place in mental processes, represented among a large number of writers by Shaftesbury, though he was in many respects a Rationalist, by Rousseau, Hamann, and many English, French, German, and Swiss writers on aesthetic theory; mysticism, which is essentially the religious form of sensibilism; German Romanticism in its proper sense, in which the individual inner feeling is singled out as the sole and absolute source of all reality, internal and external ("Gefühl ist Alles"); and finally a variety of more or less vague notions concerning the cognitive functions of "feeling," which appeared in the writings of the more popular philosophers, among whom Mendelssohn, Jacobi, and Lavater are prominent. To these movements were joined ideas derived from Giordano Bruno's cosmic vitalism and the individualistic vitalism of Leibnitz's monadology, and the strong vitalistic trend revealed in the works of many of the leading physiologists, especially of Haller, on whose *Elementa Physiologiae Corporis Humani* (1758) "the foundation of modern physiology as an independent branch

of science," [1] Herder based the final version of his psychology.[2]

As these various and often clashing tendencies entered literary thought, they gradually merged in a fundamental unity of intention, which, obscure and confused at first, attained, in the works of Rousseau and Hamann, to considerable clarity, producing the movement of Vitalistic Naturalism.

The philosophical thought of the age was dominated by vitalism. With the exception of de la Mettrie, Helvetius, Holbach, and the French Encyclopedists and their followers, even the leading physiologists, like Haller and Blumenbach, the former's successor to the chair of physiology in Göttingen,[3] assumed a primary, immaterial, spontaneous vital force, a teleological principle, determining the mechanism of nature. "Nature," in its general significance, embodied the ultimate totality and source of given existence. The particular meanings attributed to nature in that age are legion; but the assumption of a principle of development requiring no conscious planning or designing, no deliberate exertion of will, no conscious criticism of reason, no "universal, absolute, necessary" rules, no deliberate initiative; the naive belief in the objective reality of a condition of primitive "naturalness," is the key to the meaning of vitalistic naturalism. Impulse-motivation, the belief in the reality and perfection of a totalistic impulse as the true expression of being, is the characteristic foundation of naturalistic psychology.

[1] William A. Locy, *Biology and Its Makers.* New York, 1915 (Holt) p. 183.

[2] *Vom Erkennen and Empfinden der menschlichen Seele.*

[3] Goethe's friend. Goethe was much shocked when Blumenbach rejected his paper on the intermaxillary bone, regarded by Goethe above all as a conclusive demonstration of his own vitalistic naturalism, which in its deductive totalism went far beyond Herder's realism. Blumenbach attributed to "matter" a "nisus formativus" (1781), which must have influenced Goethe in the assertion of his "nisus forward," another expression of his belief in the "dunkle Drang."

Essential to this naturalism is further its conscious negation of the fundamental assumptions of rationalism, especially of the primacy of "reason," of the separate entity of the faculty of reason, and of the identity of the essence of reality with the content of ratiocinative ("clear and distinct") reflection upon "empirical" or sense data.

Both the rationalistic and the naturalistic individualisms were absolutistic. In the former the individual was regarded as an agent of reason, in the latter, as a given total of instinctive perfection, the mythical "natural man," who was believed to have proceeded directly from the hand of the Creator.

Herder conceived of individuality not as an absolute finality but as the relative and variable product of a continuous process of development. Individual personality is, in his theory, the integral organic union of a primary spontaneous, with the mechanistic, principle, developing in accordance with demonstrable biological laws and in reciprocal active relations with its cultural environment. His philosophy is not naturalism, though it has retained in its earlier phases some unassimilated remnants of naturalism; nor anti-rationalism, though an anti-rationalistic animus is sometimes unduly salient. It is essentially a consistent Genetic Vitalistic Realism, the method of which is inductive biological and historical demonstration and inference. It is a new philosophy, more comprehensive than the others, and more modern, including the first modern system of organic psychology.

Genetic individual personality is according to Herder the primary factor of all reality. It acts in an integral unity of all its powers. Reason is only one of the functions of the total personality;[4] it is not superior to, not even pri-

[4] It appears that at the present time the pluralistic conception of personality ntroduced into psychology by William James is again encountering opposition from a theory of an integral principle of unity; or, in more formal terms,

marily distinct from, any other faculty or rather, function. The will is another such integral function. There is no reason, no will, which is not also judgment, imagination, memory, perception. Reality, aesthetics, ethics are subject neither to formal, universal rules given by separate faculties of the mind nor to the arbitrary impulses of instinct, but to genetic criteria derived from the history and organic nature of personality. Beauty, for instance, is not to be judged by an objective universal standard, but to be measured as a specific manifestation of individuality involved in each given work of art. It is not a problem of objectivity but of personality; determined by an inductive, genetic judgment, not by an arbitrary or subjective guess or preference. The problems of ethics, and of knowledge itself, are fundamentally not different from that of beauty.

Herder's psychology developed in three principal stages. The first, represented by the fourth *Kritisches Wäaldchen*, 1769, is characterized by his conception of the intellectual unity of the mind. The second, identified with his essay on the *Origin of Language*, 1770-1772, contains his conclusions upon the specifically human factor of the mind. The third, shown in its gradual development in the three versions of *Vom Erkennen und Empfinden der menschlichen Seele*, 1774, 1775, and 1778, offers his final interpretation of the organic constituents of the mind. The ideas of the second stage modified in accordance with those of the third, reappear in the third chapter of the fourth book of *Ideen*, 1784.

that the view of personality as a sum of characters is beginning again to yield to the view of it as a product of multiplication, i. e., a simultaneous synthetic rather than successive additive function.

Viertes Kritisches Waldchen, 1769

The Intellectual Unity of the Mind

The unity of the mind has in a sense been always asserted by philosophers. A certain central office of cognition is a presupposition necessary for any coherent conception of the mind. But rationalism and associationism had defined a number of fundamental faculties[5] so different in competence, methods, and purposes, that the unity of the mind was a merely verbal postulate without content. Naturalism, while shifting the stress from ratiocination to feeling, had taken over on the whole the terms of traditional psychology. The psychology of the early environment of Herder dealt with three fundamental faculties: that of knowledge, that of moral conduct, and that of aesthetic judgment. These were defined in a considerable variety of ways.

The faculty of knowledge was identified by rationalism with ratiocination, or in the terminology of Kant, with the "theoretic reason"; by the adherents of the "common sense," with a primary, non-analysible faculty of common sense, a "qualitas occulta" as it were, an additional mystic sense, delivering its judgments by an immediate, simple, autonomous, oracular response; and by the naturalists, who regarded ratiocination as a sophistical perversion of the true mind, with a primary, totalistic impulse, expressing itself in unerring intuition. The "common sense" theory is thus seen to stand midway between rationalism and naturalism.

[5] First elaborated by Francis Hutchison, in his *Inquiry into the Original of Our Ideas of Beauty and Virtue*, and *A System of Moral Philosophy*. His principal followers in Germany were Crusius and Darjes; also Klotz, Lessing's favorite chopping block.

The ethical faculty was designated by all as the conscience. This was, according to rationalism, embodied in the will, conceived as the power of ratiocinatively conscious and absolutely free and responsible purpose and choice. According to the doctrine of common sense, it was another "qualitas occulta," analogous to the faculty for knowledge. In the naturalistic view, it was another function of integral, obscure, but perfect impulse.

The aesthetic faculty, in the rationalistic doctrine, was a rather embarrassing power lying midway between theoretic reason and will, being capable neither of judgments of truth nor of postulates of the will, but acting as the expression of some form of preference, called taste, or sense of pain and pleasure, or play impulse, or "feeling," or "approbation." The modern term "appreciation" as the purpose of a general cultural concern with art and literature is the false heritage of eighteenth century rationalism. The "common sense" theory labeled this faculty as the third of the mystic super-senses, as the final "qualitas occulta," pronouncing its verdicts in the same immediate vatic way as the others. Naturalism regarded this power as a third impulsive interpreter of "Nature." And as there was an indefinite variety of notions of nature, so there was chaos in the naturalistic meanings of the aesthetic sense. A common tendency of all the branches of naturalistic aesthetics was toward greater literalness and detail in the depiction or "imitation" of all the concrete data of nature, as to objects, purposes, composition, and technique. Some naturalists insisted more on faithful accounts of the emotions ("Empfindsamkeit"), of courses of impulse and obscure inward sensibility, of the supremacy of individuality (superman); some on literal accounts of objective natural, social, political conditions; some on individual and local peculiarities of manner and speech ("idiotisms"), on local

color, on "natural" dialogue, on intimate individualization generally.[6]

The locus of these three fundamental faculties was the "soul."

Herder's attack was directed against the reality of this tripartite division of the soul. He chose Riedel's *Theorie der schönen Künste,* published 1769, a rather insignificant, yet at the time prominent work, in order to gain an approach to popular attention. Riedel had stated that man has been endowed for each of his three ultimate ends, "Endzwecke," with a separate fundamental faculty ("Grund-Kraft"); namely, "for the True, with the sensus communis; for the Good, with the conscience; and for the Beautiful, with taste."

"The *sensus communis* is the inward sensibility of the soul[7] by which the latter becomes immediately convinced[8] of the truth and falsity of anything." The other two faculties are defined analogously. Herder, seizing upon the phrases "inward sensibility of the soul" and "immediately convinced" as the essential terms in the theory of fundamental faculties, shows that "inward," cannot be separated from "outward" sensibility, but that both are continuous parts of the process of sense perception. The term "immediately convinced," can mean only "to be convinced without inferences and conclusions, without judgments, exclusively through single perceptions."[9] Such absolutely single and immediate impressions, since they can have no element in common, would be absolutely isolated notions, "Inselbegriffe." They would turn the mind into a chaos of absolutely unrelated units. They could not involve discern-

[6] There are considerable traces of this naturalism left in Herder's *Fragmente,* his first immature essays, and some even in *Ossian,* and *Shakespeare.*

[7] "Das innere Gefühl der Seele."

[8] "Unmittelbar überzeugt."

[9] *Herder's Sämmtliche Werke, herausgegeben von Bernhard Suphan.* Berlin. Weidmann. (S. S. W.)

ment or interconnection. They could not produce conviction, because conviction rests on judgments of interrelations. They could bring about no development, since development requires continuity.

A fundamental faculty could produce only the most elementary notions. In reality, however, the three conceptions, the True, the Beautful, the Good, are the most comprehensive abstractions of which the mind is capable. They are not the initial but the final terms of thought and must therefore be the final products of all the mental powers.

The conception of mind presupposes an active bond of interrelation not only between the different impressions contained within the same mind but between different minds.

This common bond, the principle of the unity of the mind, is the subject of the remainder of the essay. Herder discusses it from three points of view: the genetic, that of the actual individual development of mental powers; the logical, that of the processes of judgment involved in reaching the ultimate conceptions of true, beautiful and good; and the functional view of the relations between sense perceptions and abstract ideas. Of these three, the logical view embodies a new contribution to the philosophy of his age. The genetic and the functional views, while also original, are common to all his conclusions.

1. The genetic view. Herder's interesting discourse on the genesis of ideas within the mind may be summed up in the following quotation:

"Premising our distinction between perception, judgment, and conclusion, let us revert to our childhood. How did we acquire our first ideas of objects, of their densities, colors, shapes? Did we get them immediately through a single perception? Surely not; but through many separate perceptions, through periods of setting up one against another, through comparison, through judgments, we learned

to know them till we arrived at conviction. The ideas of height, of width, of distance, are no immediate perceptions as can be easily proved by our frequent errors and by the simplest experiments in reflection. All these ideas are late judgments, the results of many conclusions, faulty always at the beginning and frequently even now. And these are only the simplest, most concrete ideas of objects which seem in such close contact with the organs of immediate perception." . . .

The much more abstract conceptions of truth, goodness, beauty, must come at a much later stage.

Growth involves a constant multiplication and complication of mental processes. But at the same time there develop also simplification and acceleration produced by habit. It is these that produce the illusion of immediate perception. "As our processes of judging and concluding become habitual and rapid we fancy that we receive immediate impressions. We omit intermediate parts and think of our logical conclusion as a simple intuition; we obscure the connection of our ideas and mistake our judgment for an immediate perception."[10] The theory of fundamental faculties has arisen from this telescoping of mental processes.

2. As to the third, the functional, view, set forth in the last part of the essay, it is unnecessary to say more than that it embodies an interesting and rich statement of the senseistic theory of the specific parts taken by the different senses in the formation and expression of ideas, particularly through the arts. In the latter respect, the fourth *Wäldchen* is a continuation of the first, on *Laocoon*, and leads over to Herder's *Plastik*, published 1778, the year in

[10] Op. Cit., p. 9. "In der Schnelligkeit und Gewohnheit urteilen wir, schliessen wir und glauben noch unmittelbar zu empfinden; wir lassen Mittelglieder aus, und der Schluss scheint ein simples Urteil; wir verdunkeln den Zusammenhang der Begriffe, und das Urteil scheint unmittelbare Empfindung."

which appeared also the final version of *Vom Erkennen and Empfinden.*

3. The middle part, dealing with his analysis of the mind as reason is the most fundamental. The revolutionary import of his conclusions has been overlooked by all the students of Herder, including Haym, principally because, caught in their preoccupation with the influence of Leibniz on Herder, they failed to realize that this essay was as much a fundamental departure from the philosophy of Leibniz as the first *Wäldchen* had been from the theories of Lessing.

As Herder had done in the first *Wäldchen,* he developed in the fourth his conceptions first in relation to the Beautiful. He again used a work by Riedel, *Briefe an und über das Publikum,* as an opportune point of attack.

The theories of "taste" [11] chiefly occupying the thought of the time had been conveniently classified under the three heads of Aristotle, Baumgarten, and Home. Aristotle had, according to Riedel, derived his laws from analysis of masterpieces; Baumgarten, from definitions of principles; and Home, from perception and feeling. Riedel rejected all, replacing them by one of his fundamental faculties. Herder, after disposing of Riedel's "faculties," reanalyzes all the known theories, revealing a comprehensive knowledge of the entire literature upon the subject of beauty. He concludes that a critic cannot dispense with any method of reasoning and any data of knowledge. All good critics proceed by analysis of the essential qualities of the best examples of beauty, i. e., by induction, after the manner of Aristotle. But since induction without definition and deduction is incomplete, they join Baumgarten's method to

[11] The term "taste" was opposed to "reason" apparently first by St. Evremond. See, regarding him, Bouhours, Voltaire, Batteux: von Stein, *Die Entstehung der neueren Aesthetik,* pp. 92-95. The rationalistic confusion of "taste" and the mental processes involved in judgments of beauty is unfortunately dominant even now, a century and a half after Herder's fourth *Wäldchen.*

that of Aristotle; and since further the significance and truth of judgments depend on the richness and accuracy of the evidence, the best critics cannot ignore the vast stores of perception and feeling opened by Home and his followers.

The sense of beauty, or taste, he concludes, is not any special faculty but the same mental activity following the same inductive-deductive methods and acting upon the same data of perception and "inward" feeling as any other type of judgment. It is different only in operating toward a different end.

Herder prepares for his conclusion by correcting an important confusion retained by Baumgarten. He distinguishes in literature between creative writing, beautiful writing, and critical writing on the beautiful. The former too are not analyzable. They aim at the production of beauty. They are "Nature," "primary evidence in matters of the beautiful," and as such beyond definition. Only critical and interpretative thought is concerned with judgments upon the beautiful. This is a true science and philosophy. It follows the methods of all science. Its analysis includes both the objects of the arts and the aesthetic perceptions and emotions. The former are the objective, the latter the subjective matter of aesthetics.

As to the objective data[12] "the science of aesthetics proceeds from and not with the (creative) aesthetics of nature; rather in the opposite direction. It breaks up into their elements even those customary combinations which in the latter were beautiful nature and thus (in a sense) destroys them. It divides into its elements (the whole of a work of beauty) and tries to recombine these elements into clear and distinct ideas: Truth takes the place of beauty. Now there is no longer the body, the idea, the work of art, the effect of which lies in its concrete aspect;

[12] *Op. Cit.*, p. 24.

beauty, divided into its constituent parts, is to appear as truth."

As to the subjective factors, the science of aesthetics "fixes[13] its attention on the past perception and sentiment, tears part from part, abstracts parts from the whole—leaving no beautiful whole, but beauty torn asunder and mangled. Thus it examines all the parts, reflects, joins them together again, in order to recover the original impression, and compares again the parts. The more precisely it reflects, the more discriminatingly it compares, the more distinct will be its final idea of beauty. Thus a distinct idea of beauty, though a conception wholly different from an obscure feeling of beauty, is yet no contradiction in terms."

In this conclusion, despite the occurrence of typical terms like "clear and distinct" "confused and obscure," Herder's opposition to the philosophy of Leibniz is obvious.[14] So far from being merely "sinnliche Erkenntniss" ("obscure and confused perception"),[15] the science of the beautiful is "the most severe philosophy,[16] a very worthy and a very difficult correlative conception (Inbegriff) of the human soul and the objects of nature. It does not desire "confused" ideas, nor does it aim at (didactic) correction of errors. The latter is the purpose of secondary ideas derived from it. Nor does it aim at interfering with the creative process, by displacing the creative, through analytic ideas." "Aesthetics is science."

Again:[17] Aesthetics! Most fruitful, beautiful and in many respects latest among the abstract sciences!" . . .

In accordance with this scientific character of aesthetics the "rules must not be regarded as regulations. They are

[13] *Op. Cit.*, p. 23.

[14] See *Op. Cit.*, p. 24f. This was Baumgarten's definition of the judgment of beauty.

[15] The "petite perception" of Leibniz.

[16] "Selbst die strengste Philosophie. *Op. Cit.*, p. 25.

[17] *Op. Cit.*, p. 21.

merely observations, interpretations, genetic (entwickelnde) generalizations for philosophers, not for autonomous creative geniuses." [18]

Herder then applies the same methods of analysis to the problems of the true and the good, and reaches analogous conclusions.

The most important result of his argument is that not only the judgments of the true, but the judgments of the beautiful and the good as well, are integral functions of reason and therefore equally cognitive. He destroys the tripartite division of the mind, rejecting any "partitions" between different functions, and defining the mind as an integral active unity combining all the data of consciousness into different types of judgment: "Einheit im Grunde, tausendfache Mannigfaltigkeit in der Ausbildung." [19]

Herder limits himself in this essay to the details of the aesthetic operations of the integral mind. We may retain the term "taste" as a name for one of the three main types of judgment. "There can be no true aesthetics without a combination of these three ways (of Aristotle, Baumgarten, and Home, i. e., of induction, deduction, and sense empiricism and feeling), which are in reality only one way. True aesthetics chooses the method of philosophy, namely strict analysis; it takes as great a number and variety as possible of objects of beauty. The critic tries to receive first the full undivided impression of the whole. Then out of the depth of this total impression he reflects his own (whole) self back upon the object. Now he observes its parts both separate and in combination, permitting himself no wretchedly pretty half-idea; classifies all his separate conclusions under their proper heads; the latter again under more general heads; until finally he may attain to a

[18] *Op. Cit.*, p. 19.
[19] *Op. Cit.*, p. 34.

single general principle embracing the universe of all beauty in art and science." [20] A better summary of the process of inductive analysis applied to art could hardly be found.

Having established the intellectual unity of the mind, he finally relates it to his conception of the primacy of personality by giving an account of the genesis of the ideational functions of the latter. Man is neither physically nor mentally absolute. He is an organic combination of mechanism and spontaneity. The animal part (Tierseele) of the soul is far more extensive than the human part. Culturally, also, he is and should be far from absolute. He is largely an expression of his environment.[21] "Not in all latitudes is human nature, as we perceive it, the same." And consequently "nations, centuries, ages, men, do not all attain to the same degree of aesthetic development." "Each taste has to be interpreted through times, manners, and nations." [22]

The faculties of man, while thus not absolute, are however, by virtue of their organic nature, capable of continuous development. Thus taste, for the very reason that it is not single or absolute, must not be arbitrary or static. "It is possible to overcome egoism, whether this be innate or acquired from one's environment, to free oneself from the irregularities of too singular a condition, and, ultimately released from the peculiarities of national, temporal, personal taste, to grasp beauty wherever found, in all times, among all peoples, in all arts and all kinds of taste. . . . Happy he who can thus enjoy beauty. He is initiated into the mysteries of all the Muses and of all times and memories and works. The sphere of his taste is unlimited as the history of mankind. Its periphery lies through all the centuries and their works; its center is he."

[20] *Op. Cit.*, p. 21.
[21] *Op. Cit.*, p. 38.
[22] *Op. Cit.*, p. 41.

Singularity, egoism, arbitrariness, exclusiveness, absoluteness, limit development and diminish the fulness of true genetic individuality.

It is evident that one of the principal subjects of the later controversy between Herder and Kant is clearly defined in this essay. Kant, though he refused to recognize psychology as part of philosophy, based his analysis of "reason" in his *Critique of Judgment*, 1790, upon three "fundamental faculties" which are essentially identical with those accepted by Riedel. He contradicted in effect the idea on which rested Herder's philosophy of genetic individuality. A final reckoning was a historical necessity and an intellectual obligation for both. The current accounts of the conflict by Herder's irritation over Kant's patronizing review[23] of the first book of *Ideen*, i. e., by something that happened sixteen years after the virtual joining of the conflict, in the fourth *Wäldchen*, is beside the point.

Herder speaks frequently of physiology as the science of the mechanistic part of the unity of the mind. But he does not yet show any acquaintance with the scientific physiology of his time, founded by Haller through the *Elements of Physiology*, 1758. His conception of physiology is still largely that of the later senseistic-associationistic ideology. It remains essentially the same in his essay on the origin of language.

While he makes a revolutionary advance in establishing the integral unity of the functions of the mind, he still follows the rationalistic tradition to the extent of identifying mind with ratiocination. The result of the fourth *Wäldchen* is an extension not so much of the meaning as of the range of cognition.

The next step in his psychology is an analysis of the spe-

[23] 1785. See *Kant's Werke, hrg. von der Königlich Preussischen Akademie der Wissenschaften* (Berlin, 1912), Georg Reimer), Bd. viii, pp. 45ff.

cifically human character, i. e., an effort toward a further individualization, of the mind.

Uber den Ursprung der Sprache

Goethe tells[24] that he read the manuscript of this essay, practically completed, before the end of 1770. The work, which received the prize offered by the Royal Academy of Sciences in Berlin, was published in 1772.

[25]The older theories concerning the origin of language can be grouped in four classes, namely that of imitation, that of invention or agreement, that of natural sounds, and that of direct divine origin or the miracle theory. The first two correspond to the account of the origin of language "thesei," the last two to the account "physei," first systematically discussed in Plato's *Kratylos*.

The theory of "imitation" supposes that language "imitates," or symbolically renders mental images or conceptions by sounds understood actually, though in a manner theoretically not accounted for, as tokens of real meanings. On account of its comprehensive simplicity and directness this theory is the oldest and in modern refinements upon the crude original term "imitation," the most prevalent. Herder by using for the motto of his essay Cicero's saying: "Vocabula sunt notae rerum," indicated his conception of the primary relation of language to things. He adopted Locke's sense-istic-realistic conception of words as "signs" of objects, and expanded it into his comprehensive theory of active sound and speech symbolism, or onom-

[24] *Dichtung und Wahrheit*, Book 10.

[25] Cp. to the following: Steinthal: *Der Ursprung der Sprache im Zusammenhang mit den letzten Fragen alles Wissens*, 4th ed., 1888. *Der Ursprung der Sprache*, in *Zur Psychologie und Ethik, Zehn ausgewählte Abschnitte aus W. Wundt.* Von Dr. Julius A. Wentzel (Leipzig, Reklam), pp. 1-58. Also W. Wundt, *Völkerpsychologie*, 3rd edition, 1911. Vols. i (1911) and ii (1912): *Die Sprache*, etc.

atopoeia. This he combined with his own theory of integral genetic personality and so laid the foundation of the modern genetic science of language.

The theory of invention of language, or of agreement upon it, which flourished in the seventeenth and eighteenth centuries, was the product of Rationalism. It assumed that Reason had deliberately invented means of expression appropriate to itself. Herder disposed of this theory by showing that such an act of instituting language implied language as already, within the Reason, existent.[26]

The theory of natural sounds had two chief phases, the earlier, "interjectional," and the supplementary later, named the "accidental" one. It supposed that all language had developed out of natural, universally understood animal cries ("bow-wow"-theory) and in addition to these, out of accidental cries and sounds, which, though originally without significance, were by usage connected with certain meanings. Herder, in criticizing this theory, uses again the argument of "Inselbegriffe," isolated notions, which in the fourth *Wäldchen* had proved conclusive in his refutation of the fundamental faculties. He shows, that the most important function of language is not the voicing of images and notions as such, but of interrelations between them. A language based on natural sounds could result only in a chaos of isolated single impressions.[27]

The fourth theory, that of the "miraculous" origin of language, can have two meanings. It can either suppose literally that language was a divine gift to (the first) man.

[26] The "root" theory also should be considered as a branch of the theory of invention. For it rests on the assumption essential to Rationalism, that the most abstract term of discourse is the primary term.

[27] A purely mechanistic interpretation of the naturalistic theory had been made by Condillac, in his *Essai sur l'origine des connaissances humaines*, vol. ii. Herder applies to it also his criterion of the relational function of language: "Form and refine and organize as you may those cries, without the mind, which subordinates sounds to conscious intentions, I do not see how deliberate human language can develop solely in accordance with that natural law." (*Op. Cit.*, p. 17.)

In that meaning it would be a part of the legend of the Golden Age. It assumes that language was from the beginning perfect and complete. Growth would be impossible; any change, a deterioration, a human corruption. This theory is contrary to all our knowledge of biological and historical processes. Herder also shows that Rousseau's compromise between the theories of naturalism, rationalism, and miraculous origin, embodied in his doctrine that God had given to man not language itself, but "réflexion en puissance," "potential rationality," in order to enable him to invent a language,[28] combined the faults of all three. "Réflexion en puissance" presupposes reason, the power of reason to make a language presupposes language, the theory of natural sounds leads to a chaos of isolated notions; and the doctrine of original perfection, as part of the legend of the Golden Age, is contrary to historical experience.

The other meaning of the theory of the divine origin of language is irrelevant. It is part of a general faith in the ultimate divine origin of all things and therefore equally compatible with any specific theory of language. Herder himself, pressed partly by the importunities of his friend Hamann, partly by the gradual intensification of his theological faith, emphasized this general implication, but without modifying essentially his specific theory, twelve years later, in *Ideen*.[29]

In developing his own theory Herder realized that the problem of the origin of language was dependent on that of its nature. Of the actual beginning of language no evidence exists. Even the most primitive races of men are at immeasurable removes from their physical and cultural beginnings. The civilized child learning his language finds himself in a physical and cultural environment alien to lit-

[28] J. J. Rousseau, *Essai sur l'origine des langues*, Oeuvres complètes 1824, ii, pp. 426ff.

[29] 1784. Bk. iv, Chap. 3.

erally primitive conditions. There is no prospect of our ever being able to isolate the actual primary factors in the growth of language. We are limited to analyses of the given complex phenomena of languages, controlled by a hypothetical general assumption.[30]

In Herder's own words:

"A subtle metaphysical language belonging to a late period of thousands of years of development, which is a variant, removed perhaps to the fourth degree[31] from the original primitive mother of the (language of the) human race, and which even as such has been refined, civilized, and humanized through the many centuries of its life—such a language, the child of reason and society, can know but little or hardly anything of the infancy of its original mother tongue."

Herder accordingly shifted the fundamental inquiry from the origin to the essential character of language. "Since men are the only speech creatures whom we know, and since they are distinguished specifically from animals by language, the surest way to discover the origin of language would be through our entire experience of the specific difference between animals and man." [32] He proceeds in his usual inductive, individualizing manner. He seeks for the one constant element which is never absent in any of the demonstrable forms of behavior characteristic of

[30] We may expect that the almost superhuman cunning of experimental science in isolating crucial factors may devise experimental tests, both intellectual and functional, which will advance our knowledge of the primitive factors of language. But even these tests will yield different conclusions as they are devised and interpreted in accordance with a strictly monistic-mechanistic, or a dualistic-vitalistic hypothesis. The former is the hypothesis of modern strict behaviorism (see John B. Watson, *Psychology*, 2nd edition, Chap. ix: "The Genesis and Retention of Explicit and Implicit Language Habits"); the latter, which has assumed a great variety of forms, that of the ruling systems of psychology since Herder, including those of Wundt and James.

[31] The four degrees are: "Sinnlichkeit" (simple perception), Instinkt, Phantasie, Vernunft.

[32] *Op. Cit.*, p. 21.

human beings and never present in any of those animals. Since this differentiating constant is universally recognized as "Verstand" or "Vernunft," i. e., mind, Herder's fundamental aim is an inductive determination of the essential factor of the human mind. His argument is briefly as follows:[33] The fewer the essential powers and aptitudes and the narrower the innate range of the constructive impulses of a living being, the more instinctive are their functions. A creature with only one impulse would be directed wholly by instinct. On the other hand, the more varied the activities and functions of living beings, the greater the need for a special coordinating function. The principal difference of man from animals can be shown to consist in the vastly greater variety of his "sensibilities, aptitudes, and constructive impulses." The powers of his soul are spread over the world." "The larger the sphere of activities, the greater the differentiation of the perceptive powers." The mind of man would be in a helpless condition of chaos without a supreme coordinating power. The function of this power is the discovery of the "third term" between any given sets of different conditions calling for adaptation. The specifically human factor of the mind then is the faculty for the third term, i. e., abstraction, or reflection. Herder calls this "Besonnenheit."

Language holds an analogous place among the various forms of expression. It has the function of coordination between the various types of sense communication.[34] The "inner word," the "word within the soul," is part of the process of reflection. It constitutes "Besonnenheit."

There can have been, therefore, no separate origin of

[33] *Op. Cit.*, p. 22ff.

[34] His argument in support of his theory of the sense of hearing as the "middle sense," i. e., as the mediator between the other senses, is derived from the sense-istic-associationistic psychology of his age, and involves some false and symbolic analogy. The conception of language as the most important function of ideational coordination, does, however, not depend on the assoliationistic view.

language. Mind and language must have developed simultaneously to satisfy the organic necessity of a supreme coordinating function within the growing diversity of impulses.

"Language is the real external, as reason is the real internal, character essential to our species."[35]

"Since rationality is the essential character of the human species, language must be likewise. To make his language is therefore as natural to him as to be man."[36]

Reflection and language are the index of the richness and unity of the mind of man. Herder interprets the latter, as always, vitalistically, i. e., as a primary individual spontaneous power developing in reciprocal organic unity with physical structure and function.

The power of reflection-language is integral. It cannot be understood as a special faculty superadded to other powers which man might have in common with the animals, but as an essential factor common to all the human powers. "The difference of man from animal is not in degrees or separate additions, but in an essential divergence and unfoldment of all his powers."[37]

"If a human being could have ever done a single action, in which his mental state was completely that of an animal, it would follow that he was not a man at all, that he was capable of not one human action. If he could be without reason for one moment, it is incomprehensible how he could have reason at any moment in his life, unless the whole economy of his nature were changed."

"Properly considered, man's rationality, which is characteristic of the species, is the total relation of his reflective power to perception and impulse.

He supports, as usual, his analysis by a genetic account:[38]

[35] *Op. Cit.*, p. 47.
[36] *Ibid.*, p. 34.
[37] P. 28-31. His argument involves an attack on Rationalism.
[38] Pp. 30-31.

"If rationality (Besonnenheit) is no separate power but the characteristic total direction of all the powers of the human species, then each human being must have it in the first moment in which he is man. This rationality must be present in the first mental act of an infant, just as the essential character of an insect must manifest itself in the first moment of insect existence." . . .

"But does thinking rationally mean the same as thinking with fully developed reason? Does it mean that an infant thinks reflectively or uses logic like a sophist at his desk? It is clear that such an objection does not touch the mental power as such but only different degrees of its use. "As far as a human infant is from growing talons like a hawk, or a lion's mane, he is from thinking like a hawk or a lion. His mentality is typically human, it is rationality, i. e., control of his powers in the direction of rationality from the first moment of his life."

"Besonnenheit," rationality, is the specific factor of the human mind. It is the primary individual vitalistic principle ruling the mechanism of nature with which it is organically one. As such, while in its functions organically conditioned, it is in its primary motivation "free." This "freedom," acting in reflection, language, and thought, marks the essential difference between man and animal, or pure "Nature." By virtue of "Besonnenheit" every idea ceases to be an *immediate* work of nature and becomes man's own work. No longer an infallible machine of nature, man creates the motives and purposes of his own constructive efforts.

In the deterministic interpretation of nature, in the opposition of nature and freedom, Herder anticipated Schiller's and Goethe's classic doctrine of freedom within necessity by more than twenty-five years. The influence of this

idea on Goethe's two philosophic poems *Grenzen der Menschheit* and *das Göttliche*, is obvious.[39]

The second, philological part of the essay does not concern us. Taking his view of rationality and language as an integral function of personality for his starting point, he laid the foundations of the modern genetic science of language. Modern theories of the origin of language, from Humboldt to Wundt, and after, though they mark a vast progress in philological technique, detailed information, and psychological technique, have not passed fundamentally beyond his genetic hypothesis.[40] He overstressed, indeed, in accordance with the older vitalism, the "inward" factor, the "word within the soul"; he carried in his symbolic-senseistic interpretation of onomatopoeia the theory of "imitation" too far; he erred, according to Wundt, in assuming the priority of the verb to the noun.[41] But these are matters of secondary importance. The enduring sig-

[39] Written 1781 and 1783, respectively. See my edition of Goethe's Poems (Ginn & Co.), Introduction, pp. Lvf.

[40] Professor Jespersen, in his recent book: *Language, Its Nature, Development, and Origin* (London, 1922, George Allen and Unwin, Ltd.), has collected much interesting detail on different stages and forms of language, but he has made no essential advance in the solution of the fundamental problem of the nature of language. Modern experimental psychology, with its technique of isolating crucial parts of the relations between mechanical processes and psychical conditions, would seem to offer the best prospects of essential progress.

[41] Wundt assumes the priority of the noun. His argument is (*Op. cit.*, vol. ii, pp. 9f.), that the noun has been in all languages fully developed, whereas other forms of words, especially the verb, "in vielen Fällen mehr oder weniger unausgebildet geblieben sind." From this he concludes that the "nomen substantivum in der Sprache aller Völker der eigentliche Träger des Gedankens ist." This is a case of reasoning from analogy, in which the crucial term: "Träger des Gedankens" begs the question.

The more primitive a mental process, the less discrete and analytic it is. It would seem that in the most primitive reactions of life to environment, as in that of eat-be eaten, that of desire-repel, and that of hold-let go, the relations of action or motion and of realization of entity are not separate. Thing-I-eat, etc., would hardly be analyzed into separate impressions of action and entity. The distinction between an entity and its action seems to involve a considerable degree of abstraction, which would hardly belong to the initial stages of mind. However, on this problem also experimental psychology will probably have the last word.

nificance of his conclusions lies in his hypothesis of the integral relation of language to abstract thought, or reflection, and of both together to all the functions of the human organism; in his insistence on the collection of the data, and on the inductive analysis of the phenomena, of speech; and on the development of language as part of the physical and cultural history of man.

Vom Erkennen und Empfinden der Menschlichen Seele (*Of Mind and Sensibility*)[42]

Haller's *Elements of Human Physiology* had appeared in 1758. It is the foundation of modern physiology.[43] Herder must have studied it between 1772, the year of the publication of his *Origin of Language,* and 1774, the year of the publication of the first version of his essay entitled: *Vom Erkennen und Empfinden der menschlichen Seele.* The latter, to which he attached great importance and on which he worked more than four years, represents the third and final phase of his, and the foundation of modern vitalistic, psychology.

In the *Origin of Language, Herder* still stands largely on the ground of intellectualism. The sense process still begins for him with "perception," i. e., with an elementary act of thought; the term "genetic," as applied to that process, is still interpreted in a somewhat associationistic manner; the reflective function still has, as in his conception of the "word within the soul," a certain character of intellectual absoluteness which does not satisfy the advanced physiological conception of the unity of personality.

Haller had introduced sensation ("Reiz," "stimulus"), a purely physiological nerve process, as the beginning of

[42] First edition, 1774; second, 1775; third, 1778 (S. S. W., vol. viii, pp. 236-262, 263-333, 131-235).

[43] William A. Locy, l. c.

the relations between the living organism and the "outer" reality. Perception, involving active participation of a mental factor, had thus become the second stage of the sense process. Herder found himself confronted with the fundamental problem of bridging the psychological gap, opened by Haller, between sensation and perception. His alternative was surrender of his assumption of the unity of the mind and the body, of spontaneity and mechanism, or discovery of a real, active, not merely formal or verbal, term of identity or bond between sensation and perception. To save the theory of unity, he had to discover an active middle term between any form of the mental and any form of the physiologcal sense process.[44] It is manifest that this could be only a vitalistic-organic term. The "geistiges Band," the essential factor of psychical unity, must integrate both the physical and the mental, i. e., the mechanistic and the spontaneous, principles.

The three stages of the psychic process, defined in accordance with Haller's physiology, are sensation, perception, and ideation (or "apperception"). Herder proceeds to analyze each psychologically, with his characteristic discernment of the specific factor, in order to isolate the vital character common to all.

As to sensation, he concludes:[45]

"To all the parts of the mechanism of nature, weight, thrust, gravity, motion, rest, force, inertia, elasticity," there is in us a corresponding feeling, a mental analogue. "We animate everything with our sensibility." Man "fühlt sich in Alles, fühlt alles aus sich heraus." There is no point at

[44] That Herder was keenly aware of this crisis is shown by his letter to Hahn, Aug. 5, 1774 (Haym, *Herder*, vol. i, p. 665), in which he states his problem as that of finding the "medius terminus" of "Erkennen und Geniessen" . . . als Wesen eines Geistes, eines eingeschränkten, sich vervollkommnenden Geistes." A detailed comparison of the three versions of *Vom Erkennen*, etc., with relation to Haller's *Physiology* and to the development of psychology since Locke and Leibniz, would be a fruitful subject for a doctor's thesis.

[45] *Op. cit.*, pp. 169-170.

which the purely physiological stimulus and its psychical analogue, sensibility, can be separated. "Inward man, with all his obscure powers, stimuli ("Reize") and impulses ("Triebe"), is completely one. All our emotions . . . are joined by invisible bonds and have their roots in the finest structures of our animated fibres. Every least one of the latter (Fäserchen), if we could only see it, every vessel, small or large, every blood corpuscle, whether it be in weaker or stronger motion, is affected. The courage of the lion as well as the timidity of the rabbit are inherent in the whole of their animated inward structure.[46]

Herder now rejects the last remnants of the philosophy of Leibniz. Leibniz, indeed, had recognized even the inanimate forms of reality as monads or types of individual energies. But he had been forced by his rationalism to conclude that the development of each monad within the absolute isolation of its essential being was determined by "clear and distinct" reasoning. Herder's conception of physiological sensibility as the primary psychic stage is irreconcilable with the rationalistic premise of the primacy of ratiocination. He proclaims his break with the rationalistic theory:[47]

". . . by such an abyss of obscure sensations . . . and stimuli . . . our 'clear and distinct' philosophy is horrified; it crosses itself before this hell of nethermost powers of the soul, preferring to play on Leibniz's chessboard with a few empty words and classifications, such as obscure and clear, distinct and confused ideas, cognition within and without the self, with and exclusively of, the self."

[46] *Op. cit.*, p. 178. This passage shows that Herder preceded Goethe in the conception of "morphology" as fundamental in the problem of the development of life.

[47] *Op. cit.*, pp. 179-180. It is difficult to understand, how Haym, *Herder*, i, 665, could say of this work: "Der Geist der Leibnizischen Philosophie durchweht sie (die Schrift) von einem Ende zum andern, ja, sie ist nichts als eine Summe dieser Philosophie im Wiederscheine des Herderschen Geistes."

"In my judgment, *there can be no psychology which is not at every step demonstrated by physiology.*"

Psychology, he insists later,[48] must not speculate upon the physiological part of the psychic process. It must not form deductive conclusions concerning "the conditions determining the process of stimuli, "but must demonstrate each case. "A stimulus is a stimulus *when it is a stimulus.*" "That is beyond all general word mongering and abstract prediction . . . it is new experience." After detailed analyses of perception and ideation he finds that "sensibility" is the essential factor common to all the stages of the psychic process.

"Sensibility" then is the primary expression of the fundamental vital principle, which differentiates itself functionally in sensation, perception, and ideation.

He draws from this definition a number of conclusions which are of great importance for the development of ideas throughout the German classic era and beyond.

The accepted distinctions between "inward" and "outward," even between "material" and "immaterial" are vague and largely verbal:[49]

"I cannot conceive how my soul can weave anything absolutely out of itself and create a dream of a world out of itself. I cannot even conceive how the soul can perceive anything outside of itself, of which there is no analogue within itself and its body. If there were no light, no sound in all the wide world; and if there were nothing analogous to light or sound within the soul, there could be in it no conception of either . . ."

"But does this conclusion imply that the soul is material,

[48] *Ibid.*, p. 184. Emphasis mine.

[49] *Op. cit.*, p. 193. This is aimed again at the philosophy of Leibniz especially and Rationalism generally; but also against the theory of perception of Locke and the associationists, who opposed the "outer" to the "inner" and conceived of the soul as a mere inward "locus" in which the data of the outer world entering through the senses as if floating through canals, arranged themselves into various ideas and activities.

or that there may be many immaterial souls? . . . I am not certain whether I know what 'material' and 'immaterial' means. But I do not believe that nature fastened iron partitions between the terms, because I cannot see anywhere in nature such iron partitions and should expect them least where nature has made a particularly intimate union."

"If anyone can tell me what spontaneity (Kraft in der Seele) is and how it operates within the soul, I will explain to him at once how it operates outside of its soul and upon other souls and bodies. Perhaps bodies are in reality not separated from the soul by such wooden walls as are the compartments of our metaphysics." [50]

2. Sensibility is a simpler term than thought, "that superhuman abstraction which, removing itself from every part of our sphere, places itself on who knows what throne of divinity and there creates verbal worlds (Wortwelten) and pronounces judgments upon everything real and possible. Syllogisms cannot teach the initial content of perception; for the syllogism presupposes perception." [51]

3. The integral unity of the vital principle, of which sensibility is the simplest manifestation, implies that there can be no essential but only a functional difference between the three different types of psychic operation. Consequently the distincton between different faculties is not fundamental. Even abstract reason and will are not separate.

This complete unity of an inward energy, controlling "all the actions of our soul which is both apperceptive and volitional," is "the most intimate conception of which our mind is capable."

"It is customary to make distinctions between a number of separate subordinate powers of the soul, such as imagination and foresight, poetic gift and memory." . . . [52]

[50] *Op. cit.*, p. 177.

[51] *Op. cit.*, p. 170. This is directed against the rationalistic assumptions of absolute or "pure" reason, and of "a priori" knowledge.

"All these powers, if they are to be human, good, and useful, are fundamentally one, which is mind. Without such unity, imagination is delusion; wit, childishness; memory, vacancy; sagacity, a cobweb; with it, and in the measure of its presence, all the powers which otherwise would seem antagonistic, became the concrete manifestations of one and the same energy of the soul."

"Knowledge without will is false and incomplete knowledge. There is no passion, no emotion . . . which does not become volition together with knowledge; in the best knowledge all (the parts of the vital principle) are active, because the best knowledge came from them all and lives only in them all. . . . They are weaklings, who boast of nothing but pure principles (of reason) and spurn impulses, from which alone true principles originate! They sail without the wind and give battle without arms. Impulse is the mainspring of being and must remain that even with the highest intelligence." [53]

"It seems to me, these are all empty word quarrels, whether the principle of morality lies in will or knowledge, whether in the improvement of ourselves or of others. All volition begins with knowledge, but reciprocally, all knowledge originates only with feeling. I can gain perfection only through the perfection of others as they through mine." [54]

4. *Ethical Freedom.* Freedom of action is not absolute but organically conditioned. The vital principle, interpreted as the immaterial, sensible principle of spontaneity, functions in integral unity with the mechanism of nature

[52] *Op. cit.*, p. 195.

[53] *Op. cit.*, pp. 189-199. This was written seven years before the first edition of Kant's *Critique of the Practical Reason*, in which impulse is rigorously excluded as a motive of moral conduct. It shows again the fundamental antagonism between Kant's and Herder's philosophies, and the irrelevance of attempts to account for the conflict on personal grounds.

[54] *Op. cit.*, p. 200.

and is both developed and limited in accordance with the processes of the latter:

"Our mind, however truly it be the deepest self within us, is not so autonomous, arbitrary, and detached (eigenmächtig, willkürlich und los") as it might seem. Leaving out of account even all that has been said regarding the dependence of our thinking on the senses, it is obvious that there must be some unknown nexus, some hint by which we learn how to use our perceptions. This teaching, this sense of something coming from the outside, with which we are impressed, gives to our thinking its . . . direction. With all our seeing and hearing and taking in the external flow of perception, we should grope in night and darkness unless some power of instruction had thought for us and, as it were, impressed upon us the ready forms of thought.[55] Only then could our powers rise, learn, and use themselves. For a long time, and often throughout life, we lean on the staves of infancy which have been given us; we think our thoughts, but only in the forms in which have been given us; we think our thoughts, but only in the forms others before had thought; we know that which is pointed out by the finger of such methods. Everything else is for us as if it had not been." [56]

"Generally, this birth of our mind seems so indecent to our wise men that they completely ignore it and worship their mind as an innate,[57] eternal, independent, unerring oracle. Without doubt, these wise men were never in swaddling cloths, never learned to speak as their nurses spoke, and had no limited circles of experience, no mother tongue and no human tongue. They speak like the gods; they speak "purely" and know ethereally. Nothing but the sayings of gods and of reason itself comes from their lips.

[55] Even the forms of thought are according to him not "a priori" but products of development. He contradicts the first principle of rationalism.

[56] *Op. cit.*, p. 198.

[57] The assumption of "innate" ideas is essential to Rationalism.

Everything is innate, implanted in them; the spark of unfailing reason has come to them directly from heaven; no Prometheus was required to steal it for them. Let them talk and worship their picture words; they know not what they are doing. . . . The more deeply one descends into himself, into the structure and origin of his noblest thoughts, the more humbly he will say: "What I am I have grown to be. Like a tree I have grown. The germ was there, but air, earth, and all the elements, which I did not constitute around me, had to make their contributions to the formation of that germ and of the fruit and the tree."

"The question also, whether our will is something inherited or acquired, something free or dependent, has to be answered on the same ground: that true knowledge and . . . will are one and the same, one power and energy of the soul. If our knowledge did not come out of itself, autonomous and unbound . . . truly, the will also could not have come out of itself. Agamemnon had his scepter from Thyestes; he again from Zeus, for whom Hephaistus had made it: so it is with the 'freedom of our soul,' the . . . most royal scepter of them all." [58]

"It is easy to babble of the freedom of the soul if we accept any impulse, any elusive good, as a sufficient reason. These sufficient reasons, in which the universal seems always true and the particular instance and specific case, always false! By disguising as the radiant reason of heaven the mechanism of which one is a slave, one may fancy himself free, a prisoner whose chains become in his dreams flowery wreaths. As soon as one gives way to speculation, one can make anything of everything; one fancies himself soaring into the empyrean while the poor man is still in his chrysalis without wing or spring."

[58] *Op. cit.*, pp. 201-202. The fundamental antagonism of this conception of the will and that embodied later in Kant's *Critique of the Practical Reason*, is obvious.

"The first germ of freedom is to perceive that one is not free, and to know the bounds by which one is held. The strongest and freest men who never cease to aspire, know this most deeply; mad slaves, born for the prison, scorn such men and remain, full of lofty dreams, supine in the bog." . . .[59]

These arguments, on account of the emphasis given by the satyre upon the rationalistic doctrines of "innate" ideas and the primacy of "universals," involving the deductive method of the "sufficient reason" in judgments upon "empirical" reality (Kant's "synthetic" judgments), have produced the universal impression that Herder was exclusively concerned with rationalism. In this impression lie the roots of two fundamental misinterpretations of Herder's philosophy, the first of which is the supposition that Herder's work was chiefly polemic and negative and only incidentally constructive, and the second, that he was an adherent and the most prominent spokesman of the sense-istic associationistic, and the naturalistic movements, the two principal reactions against rationalism.

Herder's argument on the active freedom of the soul and its organic limitations is as antagonistic to the former two as to the latter.

In the sense-istic-associationistic view the "soul" is merely the locus, the passive region, where somehow the various types of "impressions," which are imagined to have traveled thither intact through the senses, as if through neutral channels or, according to Locke, "inlets,"

[59] Pp. 201-202. Herder, in the passage following the one quoted sees in this theory of the organic limitation of the will the philosophical counterpart of Luther's (and Augustine's) rejection of the freedom of the will on theological grounds. Luther's doctrine of the unfreedom of the will is found in his book *De servo arbitrio*. Herder amplifies his theological theory of qualified freedom in a fine development of the theme, "Where the spirit of the Lord dwells, there is freedom," *Op. cit.*, 202. The principle of "freedom within law" which became the characteristic ideal of the classic era, was thus formulated by Herder twenty-five years before it gained literary currency through Goethe and Schiller.

arrange themselves by an occult inherent power of composition into various types of "ideas."

In the naturalistic philosophy, the essential factor actuating all the life processes is impulse conceived as an obscure, non-conscious, anti-intellectual, predestined power flowing directly from an occult source representing the absolute unity of God and nature. The confusion of Herder's synthetic conception with this mystical belief in impulse as the single and supreme motive power of life, is responsible for the general identification of his views with those of the "Storm and Stress" and even of the Romantic movements, despite the implacable severity and persistence with which he attacked these two vagaries.

Herder transformed all these movements. He brought them to the test of his original conception of the active, organic-genetic unity of all the functions of life, and gradually constructed a new synthesis, far more comprehensive and vital than any other. His philosophy was the true union of the science and philosophy of the eighteenth century. Assuming a total vital principle, he endeavored to analyze its specific relations to the demonstrated physiological nerve processes. He reduced both the conception of the mind, developed one-sidedly by rationalism, and that of impulse, proposed equally one-sidedly by vitalistic naturalism, to the simpler conception of sensibility, as the factor common to both. And he replaced the meaningless associationistic dualism of soul and senses as a neutral inward container, on the one hand, and of its contents as separate outward objects, on the other, by combining the soul and the senses into an integral, active, functional-ideational process. He concluded that the organic unity of the vital principle and the mechanism of nature involves a reciprocal relativity of the two which can be understood not by any deduction, speculation, or absolute construction, but only by particular demonstration and inductive infer-

ence. The unity of the vital principle involves assumption of one active central energy of the soul, of which the "fundamental faculties" are merely different functions.

Inherent in the method by which Herder arrived at this synthesis, is the assumption of the given organic individual, the individual personality, single or collective, as the primacy factor of reality. "The deepest foundation of our being is individual, in sensibility as well as in will and abstract thought" [60] "As single individuals, so . . . families and peoples are differentiated: their mentalities (Denkart) are conditioned by their sensibilities." [61]

The single and the collective relations between organic sensibility and thought, and between these two and character are reciprocal. Bad or good sensibility, bad or good abstract thought, bad or good character influence one another integrally. Each must be interpreted always in relation to the other two. Isolation of genetic conditions, of technique, subject matter, inherent mental, moral, and aesthetic character, is contrary to the unity which functions integrally throughout the activities of the living individual.

In the second section of his essay Herder applies these conclusions to some typical instances of fundamental cultural conceptions, particularly to art and literature, humanity and education, and the ideal man.

1. *Art and Literature*

The passages[62] on literature and art may be regarded as the "locus classicus" of Herder's view of these subjects. They are the substance of which all his later particular

[60] *Op. Cit.*, p. 207.

[61] *Ibid.*, p. 210. He sums up again the reciprocal genetic function of environment, which has been discussed in an earlier paper: *Modern Philology*, Vol. xix, No. 4, May, 1922.

[62] *Op. Cit.*, pp. 207-210.

theories of literature[63] are consistent elaborations. Literature is, according to him, not a merely formal practice of technical skill and special rules, but the highest and most complete expression of the whole integral personality. The precept given to young Goethe in 1770 that in writing poetry he should act always "mit ganzem Herzen und mit ganzer Seele," found thus its psychological justification. Literary criticism should follow the same law of unity. The standards of beauty are not contained in formal rules of technique but in the character of specific individuality. The "aesthetic" judgment functions in integral unity with abstract thought and ethics.

The term "aesthetic" is inappropriate to Herder's philosophy. It is generally misleading. Owing to its origin from Rationalism, it carries the implication of a particular "faculty," separate from and inferior to the highest "faculty" of the mind. To Herder, literature (and art), as the highest embodiment of the whole genetic mind of a people and its representative individual members, requires the full exercise of all the powers of the mind, i. e., sensibility, reason, and volition (including impulse), in unity. Rationalism subordinates beauty to "truth," the product of "reason"; naturalism, to impulse; both isolate it from ethical volition. Herder integrates it with all these functions of individual being. He does not deny or subordinate beauty, but, on the contrary, extends and raises its significance and reality.

"The deepest foundation of our being, both in sensibility and in thought, is individual. Let us observe in individual instances from what strange germs and grains the different harvest of passions grow in different persons. . . . Every book should be considered as the imprint ("Abdruck)" of a living human soul. The imprint is

[63] Especially his final formulation of his literary theories in the seventh and eighth parts of the *Humanitätsbriefe* and his essay on *Bild, Dichtung und Fabel,* in *Zerstreute Blätter, Dritte Sammlung.* § S. S. W., Vol. xv, pp. 523-568.

the more true and living, the less the author . . . filled the book with wretched generalities. . . . The wise reader, who is more modest than the shallow and hollow one, . . . proceeds as Socrates did with the writings of Heraclitus. He tries to read more the mind of the author than the book; the more deeply he enters into the former, the more clear and coherent everything becomes."

"Every poem, especially a great and whole poem, a work of the soul and the life, is also a betrayer of its author, often where he least suspects it."

"This living reading, this divination of the soul of the author . . . is the only proper kind of reading and the most profound means of mental cultivation (Bildung). It becomes a sort of inspiration, a familiarity and a friendship, which is often most instructive and agreeable in cases of difference of thought and sensibility, and which is the test of what we call our favorite authors. Such reading is emulation, heuristics; we mount with our authors to creative heights and discover errors and mistakes at their sources. The more vitally one knows his author and has lived with him, the more real becomes this "intercourse."

"The greatest factor of development in the world of the mind is the succession of courses and cycles of sensibilities, necessities, conditions." [44]

"The men who accomplished most in the world, never limited themselves to the flowers of such and such opinions but dared go down to the roots, which are in sensibility, in the art and whole conduct of life. Poets and wise men, law givers and generals, founders of religions and demagogues, all touched the hearts and thereby produced their effects upon ideas."

Thus there must be a "common sense" uniting all humanity, but it can be such only in the measure of a common human sensibility ("allgemeine Menschenempfind-

[44] *Op. Cit.*, p. 211.

ung"). This truly genetic common sense which rises from the community of all men, is the foundation of Humanität.

The passages quoted are of fundamental importance for the right understanding of the development of the literary ideas of the German classic era. They contain, in more mature form, the new conception of literature and life, which young Goethe learned from Herder at Strassburg in 1770, and by which his greatest art and his fundamental philosophy were released and begot.[65]

The far-reaching misunderstanding of that development, which is still ruling, has arisen from a confusion of two mutually exclusive interpretations of Herder's theory of psychic-organic unity. The authors of this confusion are Friedrich Schlegel, Schiller, and Goethe.[66] Later writers seem to have accepted their view unquestioningly.[67]

In the first part of the seventies, in which Herder's essay appeared, Goethe was occupied with those of his major compositions which are most characteristic of his earlier poetic activity, namely, *Götz, Werther,* and *Urfaust,* followed, about ten years later, by the first version of *Wilhelm Meister.* Their chief characteristic is the principle of naturalistic motivation of character and plot. Impulse motivation, including impulse-ethics, supine reliance on impulse-fate working through the "dunkle Drang," interpreted as benevolent, governs the composition of these works.[68] Herder's insistence on the integral unity of sensibility, reason, impulse, and ethical will, was as much in opposition to Goethe's earlier anethical naturalism as to

[65] See my edition of Goethe's *Poems* (Ginn & Co.), introduction, pp. xxiv, xxvii-xxxi.

[66] See my *Fundamental Ideas in Herder's Thought,* iv, chap. ii, *Modern Philology,* Vol. xix, No. 4.

[67] For inst., Haym, *Herder,* ii, 638-640, and throughout.

[68] See, for a somewhat detailed statement of these ideas my paper on *The Cultural Relations of the Philosophy of Kant,* in the *Monist* for April, 1925 (Special Kant number). A thorough study of the problem will be found in my forthcoming essay on *Goethe's Conception of Personality.*

the dogmatism and false atomism of rationalism. The inevitable friction resulting from Goethe's and Herder's realization of this contradiction between their views, though periodically allayed by their deep community of ideas and interests, as, for instance, after the appearance of Herder's *Gott,* by which Goethe was greatly moved, constantly recurred with increasing severity until it culminated during the early nineties in a permanent conflict. Schiller, whose mind was more akin to the rationalistic type, and Friedrich Schlegel, who in his reviews of Goethe's *Wilhelm Meister* and of the seventh and eighth parts of Herder's *Humanitätsbriefe*[69] leaned toward the naturalistic type, became at that time the dominant literary influences, working upon Goethe from opposite directions against Herder's ideas. Goethe broke with Herder, acquiescing in the two mutually exclusive charges that the latter insisted on unduly moralistic standards of literary judgments and on an unduly naturalistic subordination of literary standards to historical-genetic actuality. Even Goethe fell short of a full comprehension of Herder's great theory.

2. *Humanität. Education. Action and Mind*

Thought and sensibility cannot be developed or used separately. Nor can either be separated from action or conduct. They and conduct interact integrally.

Thinking may affect sensibility well or ill. Bad thinking, word-worship, thoughtless parroting, corrupt the sentiment equally with the reason. Thought, even the most abstract, must have lived, must have grown from the whole of life:

[69] See for references, my *Fundamental Ideas in Herder's Thought,* No. IV, *Modern Philology,* Vol. XIX, No. 4, May, 1922, pp. 369ff.

"Even the most abstract system of ideas (Wissenschaft) has its sensible side, and generally the best insight was born in business, deed, action." [70] "Mind and sensibility live only in action, the real truth." [71]

This unity is the fundamental principle also of his theory of education. He rejects both the scholastic method of rationalism, and the naturalistic method of surrender to impulse represented by Rousseau, Basedow, and the German "Storm and Stress." He is consistently realistic, aiming at a harmonious development of mind, sensibility, and conduct.

"There are no worse forms of assassination than those committed against the three gifts of God: mind, sensibility, language. It is such a murder to drill youth in abstraction and speculation. If he is successfully drilled he is wretched, senile in youth, an empty vessel, which sounds only too loudly. On the other hand, if he learns nothing except stamping on cobwebs, on how many great things beside the cobwebs will he not trample! Whose fault is it that philosophy . . . has become an object of reproach and contempt, together with its worshippers, the manufacturers of wooden tomes, theories, and systems." [72]

"On the other side there has grown up the sect of the sentimentalists, the little giants with high chests and mighty passions. Did not the great Helvetius prove in his day that genius and virtue were suited to each other as cat and dog, and that moral men were the weakest and most wretched beings under the sun? A great will, strong independence, an eternal battle with gods and demons: these make heroes, Nephilim, lions." [73]

[70] *Op. Cit.*, p. 216. Herder refers to Bacon as one of his authorities.

[71] *Ibid.* This is the source of Goethe's "Im Anfang war die Tat," introduced into his first part of *Faust* more than twenty years later.

[72] *Op. Cit.*, p. 219.

[73] *Ibid.* This satyre on the characteristic megalomania of the "Storm and Stress" seems almost a parody on Goethe's *Prometheus*, published in the same year.

He develops this passage into a classic criticism of the "Storm and Stress" ideal of the superman, the "Kraft-genie," who feels himself exalted in absolute sovereign freedom above the limitations of man; and, on the other hand, also of the opposite of the superman, the commonplace utilitarian, and of the puritan, who judges reality by formularies.

"No one can add a drachm or an ell to his strength or size; and the clamor of the youngsters on stilts following a giant, or the hee-haw of asses in lion's skins, can not long deceive. So much is certain that every great and strong soul has also a natural endowment to be virtuous. Where one passion is possible there is also possible another which counterbalances the former. And generally, why should any passion or emotion be uncontrollably directed toward evil only? Perhaps men of greater strength have to make a greater effort to conquer themselves; but by reason of their greater strength they may be called great men only after they have, by conquering themselves, become good men."

"A deep sensibility must lead also to deep knowledge. . . . We must conclude that the strongest passions and impulses properly ordered, are merely the sensible outline (das sinnliche Schema) of the strong reason within them."

Herder sums up his analysis of the relations of thought and action in an imaginative passage in which he combines the conceptions of the organic-psychic unity with that of historical-genetic development:

"The stream of the ages flows amid strange banks. It winds, like all streams and even the ocean, hither and thither at different angles. Now the configuration of the ground favors the intellect, now the sensibility, and those plants (of the mind) grow always best, which spring from the natural soil of each people, of each age. At one time all the wise men look up toward the sky and count the stars

and are nowhere less at home than in their native land, their native city. Again they go on crusades to gain the golden fleece of tolerance, universal religion, and love of man, crusades as adventurous as those toward the holy sepulchre and alien political systems. One labors to make an image of mankind with a head of gold, but with feet of clay; others make monsters, griffins, sphynxes. God lets them all work and uses one scale to balance the other. He directs sensibility through an increase of knowledge, and knowledge through sensibility." [74]

3. *The Ideal Man*

After disposing of rationalistic and naturalistic conceptions of humanity, Herder in conclusion formulates the ideal of man inherent in his own conception of personality. His ideal man combines both mind and will in an organic unity. He is not an absolute. Neither the immaterial principle of spontaneity, nor the physical principle of mechanistic determination is absolute, but both interact, furthering and limiting each other. The extent of this material relativity and the manner of its functions are not to be assumed speculatively and "a priori," but realistically and scientifically, by demonstration and inference.

Herder's ideal man is not a man thrown out of balance by the abnormal development of any one particular quality, nor the commonsense" average of men as actually given, but the embodiment of the fullest coordination of all the higher factors of individual life.

He does not consider this ideal as existing or even as attainable, but as the standard of the values of human mind, character, and condition. His "genius" is the ideal individual instance of his conception of "Humanität." This

[74] *Op. Cit.*, pp. 220-221.

modern humanism, which through its genetic, scientific, and historical character is essentially different from the humanism of the Renaissance, became gradually the central idea of modern German thought. In its continuous growth it was, indeed, broadened by the greater exactitude of modern knowledge of the genetic relations of man to his cultural environment, by a truer grasp of the laws of biological development, and by an ever-expanding realization of the social character of man. But the four crucial conceptions of modern humanism, namely: genetic history, biological growth, the social character of man, and the integral active unity of the three within individual personality, received their essential meanings at the hands of Herder.

In describing the unity, Herder continues:

"There is really only one gift in every human being, namely (the unity of) mind and sensibility, i. e., the inner life of apperception and elasticity. Wherever there is this, there is genius." [75]

"Only this inner life of the soul gives to imagination, to memory, to wit, to sagacity, and so forth, extension, depth, energy, truth. A genius may spread before us a greater variety of colors than the peacock, he may be more phantastic than Bellerophon's steed, he may produce a web subtler than the spider; yet, if mind, perception of truth, if the specifically human character be taken away, nothing remains except animal powers, in which man would be inferior to the animals." Without this "living spring," the orator becomes a mere counter of syllables, the poet a versifier or an inmate of Bedlam, the grammarian a word-monger."

This specific inward identity of sensibility, mind, and will, bears the name "genius" when the mental powers, "character," when will and sensibility are the topic of discourse."

[75] *Op. Cit.*, pp. 222-230.

The two together make up "specific individuality (einzelne Menschenart)."

The ideal man, the true "superman," is aware of his organic limitations. He "feels his weaknesses and limitations too much to bathe with the moon and the stars in the abyss of his 'positive power.' He strives and by striving proves that he lacks something. He strikes against the cover which surrounds him, the shell which encloses him, too often to his pain, to imagine himself in an empyrean of blissfulness of his own."

Departing from his custom of presentation, and evidently yielding to his sense of the fundamental importance of this essay, he finally casts his conclusions in five theses, which are here restated in paraphrased and abridged forms:[76]

1. Mind and sensibility (Denken and Empfinden) are one, and only verbally (durch Wortformeln) separated.

2. "All so-called 'pure' or transcendental reason ('reines Denken in die Gottheit hinein') is delusion and triviality, a day dream. All our thinking originated in sensibility and retains, in spite of every sort of distillation, ample traces of its origin."

3. Ridding oneself of sensibility, including the passions, does not set free an "absolute" reason.

4. Immortality of a metaphysical monad (i. e., of the spiritual principle conceived as an absolute) is nothing more than a metaphysical immortality, the physical reality of which is not convincing. If the soul is that which we feel, which all men and peoples understand, which its name (anima) implies, namely that which gives us life, the foundation and sum of all our ideas, perceptions, and powers, then no demonstration of its immortality is possible from itself. We fold in words the very thing we wish to unfold from them; we premise that which is beyond human proof,

[76] *Op. Cit.*, pp. 233-245.

even beyond human comprehension and conception. The transition from one life to a higher life, the waiting of our inner being for the judgment, the resurrection of our body to another sky and earth, cannot be demonstrated from a monad."

5. Immortality, i. e., absolute being, is not part of knowledge but an article of faith. The truth of faith is of a different order from that of knowledge. But even as such, it is not absolute but also human. It is eternal in the meaning of Spinoza, in which perfection is ideally or formally incorruptible; conceptually ultimate, but not immortal. "It is an inward token of the truth of religion that religion is wholly human, that it indulges in no futile sentimentality or knowingness ("weder empfindelt noch grübelt"), but thinks, acts, and gives strength and resource for thought and action. Its understanding is a living force: the sum of all understanding and perception. In this sense it is eternal life. If there is a common mind and sensibility, it is in faith. This side of faith is the one most misunderstood."

Herder's conception of faith as a final form of truth but not of knowledge is fundamentally different from Kant's conception of the "practical reason," which formally, in its opposition to the "theoretical reason," the Kantian "faculty" of knowledge, is analogous to Herder's "faith." Kant's "practical reason," or faith, is a separate "fundamental faculty," conceived absolutistically. Herder's faith is part of the organic and integral unity of all the functions of human being. It involves in its operation all the other functions. It is the supreme or "ultimate" form of the totality of being, and thus specifically "human" nor existentially eternal, not "a priori" or absolute.

With the essay *Vom Erkennen und Empfinden,* Herder completed the philosophic-scientific foundation of his system of thought. He made no essential alterations in this

foundation throughout his remaining thirty years of productive work. All his subsequent works were the rich efflorescence of his epoch-making conception of the organic unity of the mind. His religious views reached their classic perfection with his *Gott,* in which God is conceived, not merely, as Haym thinks, as a combination of the supreme monad of Leibniz and the pantheism of Spinoza, but as the ultimate idealization in faith, of his principle of integral personality. His political development of his conception of the ideal man, led to the conception, original with him, of the "aristo-democrat," developed in the *Humanitätsbriefe.* His genetic view of the unity of individuality reached the final expression, of its collective form, in his *Ideen,* the foundation of the modern conception of history, in his *Volkslieder,* and in his theory and practice of translation; and of its single form, in the great number of his critical writings on literature and art, the culminating parts of which are his *Plastik,* the seventh and eighth "collections" of his *Humanitätsbriefe,* and his essays on image, poetry, and the fable. His universal ideal of the motives and standards of ethical conduct, determined by the genetic unity of personality, is the central subject of the *Humanitätsbriefe.* And finally, the theoretic implications of his philosophy were consistently and exhaustively, though with painful discourtesy, marshaled against the new rationalism of the philosophy of Kant in his *Metakritik* and *Kalligone.* There was no field or fundamental topic of the thought of his age which he did not reorganize in accordance with his principle of personality.

The complexity often charged against Herder's thought is the mistaken impression caused by attempts to subject the unparalleled scope and richness of his work to the criticism of systems of thought, especially of the philosophy of Kant, which it was the inherent purport of his fundamental conception to challenge. His philosophy, seen in the

focus of his central idea, exhibits the monumental simplicity and order characteristic of the great systems of thought. His teaching was almost universally condemned by the school of Kant. Yet, even during his and Kant's lifetime and with constantly increasing momentum and range, the trend of the historical and humanistic sciences came under the sway of Herder's principles and methods. Humboldt and A. W. Schlegel were his direct disciples. The latter's "Berlin lectures," the culmination of his critical work, rested not on Romantic absolute egoism but on the historic-genetic conception of collective individuality and of literary form, characteristic of Herder's thought. Boeckh,[77] the father of modern philology, in defining philology as "die Erkenntniss des vom menschlichen Geiste Produzierten" and as "Wiedererkenntniss und Darstellung des ganzen vorhandenen menschlichen Wissens," made a somewhat immoderate restatement of Herder's view of language as the master key to all the chambers of the mind. Friedrich August Wolff's favorite saying that the goal of the study of antiquity was the knowledge of man in antiquity, was derived from Herder. In its legal and constitutional application, Herder's conception was the dominant motive and standard of K. F. Eichhorn[78] and Karl von

[77] Boeckh's *Encyclopaedie und Methodologie der philologischen Wissenschaften*, hrg. v. E. Bratuschek, 2 Aufl. v. R. Klusmann, 1886, pp. 10f., 16.

[78] *Deutsche Staats-und Rechtsgeschchte*, 1808 ff. Cp. for Herder's conception also his criticism of Montesquieu in his *Journal meiner Reise i. J.* 1769, SSW. Vol. iv, pp. 464ff. The gist of this criticism is: Montesquieu bases his conclusions on laws and constitutions only, and not on all the vital factors of national life. Further, he considers too few countries and forms of government. For the monarchy he treats France as the only instance, without considering Russia, Spain, Portugal, Denmark. He thus shows insufficient discrimination. His method is too formal, abstract, and impoverished, lacking the substance of real life. The formal conception is false, because static. No form of government remains constant; it changes continuously. Herder insists on the entire living effects of all the factors of environment rather than only on the relatively small and secondary part of it represented by formal, legal-political enactments. These ideas bore fruit in the works of Eichhorn, Savigny, Niebuhr, Ranke, and the entire "historical" school of German learning.

Savigny,[79] the fathers of modern German jurisprudence; in its general historical bearings, it was the inspiration of Niebuhr,[80] Raumer,[81] and Ranke.[82] Lotze, in his *Mikrokosmus, Ideen zur Naturgeschichte und Geschichte der Menschheit,* and in his *Aesthetik,* developed further Herder's ideas of the primacy of individuality and of the latter's reciprocal genetic relations to its environment, and Herder's psychological interpretation of individuality as an integral organic unity of spontaneity and mechanism. Wundt's psychology is essentially a further elaboration of that of Herder, in accordance with the enlarged modern knowledge of biology and physiology, and the greatly refined modern methods of analysis and demonstration.

The spirit of the historical and humanistic sciences even at the present day is in the main the offspring of Herder's genetic conception of vitalistic realism.

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[79] *Geschichte des römischen Rechts im Mittelalter,* 1815-1831.
[80] *Römische Geschichte,* 1811-1832.
[81] *Geschichte der Hohenstaufen und ihrer Zeit,* 1823-1825.
[82] His first work: *Geschichte der romanischen and germanischen Völker von* 1494-1535, appeared 1824.

NATURE AND ULTRA-NATURE

THE principle of the responsiveness of the organism to its environment is a commonplace. Too often, however, this characteristic reaction is regarded as being predominantly passive, somewhat as the sway of the compass reflects the fluctuations of the external energy field. In this respect it is not sufficient to contrast the complexity of organic change with the simplicity of the physical; for this simplicity is only the surface aspect of a bafflingly intricate constitution. It is certainly true that the lowest forms of life are almost completely subordinated to environmental influences; but even at these earliest stages there has already been inaugurated a relation, which altogether transcends mere responsiveness in the unceasing effort of every living being to dominate its immediately surrounding circumstances, no matter how restricted these may be. Thus the evolution of life, fundamentally, is an advance to an ever rising level of mastery over the environment; and all the specific reactions between the infinitely various forms of living beings are really the means whereby this mastery is maintained and more fully expanded. But it must be recognized that the prevalent tendency to emphasize the passive characteristic of organic response is the natural consequence of two outstanding features of the entire group of phenomena. For in the case of plants and the lowest animals, we find, in the first place, that the "world" of each individual organism is extremely narrow.

But whenever the observer relates such organisms to the environment, he inevitably interprets this relation in the light of the wider world of science as a whole, within which the separate organism is an almost helpless nonentity. But thus to envisage the situation is to miss its essential point. The immediate "world" of each living thing is undoubtedly very limited in its range; but within that world itself it is always the organism, and not its immediately environing influences, that is the dominating factor; for it utilizes this "world" to sustain its own existence, although at the same time it also contributes to the maintenance of some "world" that is wider than its own and to which, therefore, it remains subordinated. But not only is its dominance exercised over an extremely narrow sphere; it is itself, still further, an insignificant unit merged within its natural species or order—a private in an enormous army; and here we find the second reason why it is so often looked upon as merely passively responsive. Yet it is only necessary to consider the life of the species *as* a species to perceive that the fundamental characteristic of all life is dominance—the mastery of an environment which is either completely physical, or is a combination of physical agencies with vital; and, once again, organic evolution is the unceasing expansion of this dominance. For this constitutes the essential distinction between "higher" and "lower" types of organism; and whenever these conflict the "higher" always justifies its appellation by subordinating or even supplanting the "lower." Thus, "the survival of the fittest" means not the persistence of forms which are merely passively adapted to their environment, but always the active conquest of some portion of their surrounding world.

The application of this principle is in no degree affected by the narrow range of the primitive domination thus acquired; at the same time its patent contrast with the vast extent of the whole of nature undoubtedly makes it ex-

tremely difficult to assign to the activity of any given species its due importance. For individuals and species alike appear to be completely swamped by the onward movement of Life in its entirety, just as the affairs of a single soldier sink into insignificance when compared with the fate of the army or the nation. It is a perfectly natural consequence therefore that our attention should become concentrated on the environment, which thus appears to be the dominating agency by which all living things are moulded into conformity with its demands, as the potter's clay is manipulated by the artist. There is, of course, a very large element of truth in this view of the relation between environment and species; but when it becomes emphasized to too great a degree it distorts our comprehension of the manner in which organic evolution proceeds. This is the real basis in my opinion, of the current criticisms of the controlling influence of natural selection. For, if selection is nothing more than a persistent pressure arising from some wholly external source, then it at once becomes necessary to appeal to those internal factors which alone can truly explain the unceasing advance of Life and Mind, as has recently been done in the case of Lamarckianism and mutation. Evolution, in other words, is an essentially immanent activity; it must be explained not from without but from within. But when we regard every individual living being, not as helplessly manipulated by some selective factors from outside itself, but rather as actively determining, to some degree no matter how minute, the fate of all its fellows, natural selection is at once seen to constitute the final referendum which settles the destiny of each and all. It is the fierce incessant interplay of all the great vital forces one upon the other, including within its range, and therefore contributed to by, every distinguishable agency such as heredity or "spontaneous" variation.[1]

[1] Cf. Dr. Bosanquet's remarks, *Value and Destiny*, Lect. III, ii.

But this always characteristic dominance of life only becomes markedly effective as consciousness attains its higher stages of development; and its "emergence"—to employ a valuable current terminology—again presents two features that are frequently overlooked. For consciousness is really the highest form of life; it is the life of mind, or life that has transcended the level of protoplasmic processes so as to become the to us as yet inexplicable interaction between the psychical and the physical. As such, still further, it plainly manifests the swift expansion of life's mastery over its environment. For conscious experience is never merely passive but always essentially dynamic; it never remains contemplative and nothing more, but incessantly employs the results of contemplation as the means for controlling and altering its world. This principle is true not only of practical action but equally of knowledge and art; for these, no matter how "pure" they may be, are not simply a knowing and an enjoying,[2] but attitudes inseparably one with effective doing; they are the modes which the dominating life of mind steadily assumes as it progresses beyond its primitive forms in the instinctive experience of animals. For from the all-inclusive standpoint of biology animal instinct may be compared to the unconscious life of plants. In both these spheres alike life operates most effectually through the species rather than through the individual; and thus the main plant subdivisions are paralleled by the different types of instinctive behavior. Instinct is undoubtedly mind; but as compared with the independent self-consciousness of humanity it may be regarded as the plant-type of mind—as mind which reproduces, in the psychical sphere, the conditions of plant species in the protoplasmic sphere. Its principal forms are (relatively) fixed, hereditary and inescapable; and thus it safeguards the separate

[2] I am not here using "enjoyment" and "contemplation" in Dr. Alexander's epistemological sense.

organism by merging it within its species—by maintaining over it a despotic control from the beginning to the end of its existence. It is in this manner that life overcomes the helplessness of the primitive mind of the individual animal. Every animal—every living thing, in fact—is (as I have already argued) dominant over its immediate environment; but this environment, in each separate instance, is so limited that it is only by operating on the large scale of specific instincts that the dominance of life can be sustained.

Yet even in the highest animals its ascendancy remains always a bodily superiority; it never becomes the dominion of pure mind. For instinct, after all, subserves only the animal's physical necessities—a fact exemplified in the relatively small size of the entire brain on the one hand and the marked development of the olfactory region on the other. But with the evolution of the higher cerebral centers underlying thought and ideation, mind slowly assumes its pure and proper form; and this further advance necessitates that its influence over the outer world shall be exerted, no longer by means of the species, but always through the individual. This fundamentally important change is, in the first instance, the inevitable result of the subjectivity of the new contents of the mind—of the concepts which form the raw material of reason and knowledge. It is true, of course, that a subjective aspect is possessed by all forms of consciousness without exception; but at the same time the entire range of animal experience is directed towards the external objective world which is, in one form or another, common to all experiments alike; and it is irrelevant whether we explain this community of awareness by a realistic, or a so-called "idealistic," theory of perception. All that matters here is the ultimate result, which may be alternatively expressed by saying that animal consciousness remains at the level of sense-perception. But whereas this forms the highest achievement of the animal,

and also to a great degree of the savage mind, it is only the lowest stage of human mentality. For even the crudest beliefs of the most primitive races imply the development of a powerful imagination, as also of that real though perverse logic which marks the dawn of childish thought; and thus the evolution of mind makes the vital advance from perception to conception—from sense to reason—from feeling to artistic imagination. But, once again, all the raw materials of these higher intellectual activities are from the psychological standpoint subjective; they are not shared by our fellows in the same way as the perceived objective world, but are, in the first instance at least, restricted absolutely to the private consciousness of each individual; and this primary subjectivity not only constituted a difficulty of the first order in the early course of mental evolution, but still forms the most serious obstacle to the development of all higher education. For this development, in its purely psychological aspects, always consists in the further increase and organization of those elementary concepts which spring up naturally in every human mind; but in the vast majority of cases this is prevented from the outset by the continued predominance of sense-experience, so that the individual remains always at the perceptual level precisely as does an animal, except for the fact that natural instinct has been displaced by the control of custom, convention and habitual routine.

It is nevertheless this conceptual content that gradually attains, as reason advances, an ever widening sway over all human activity. But since it remains always psychologically subjective, its guidance must be exerted wholly from within, and thus directly and solely upon each separate experient. In other words, the influence of reason is (firstly) internal and (secondly) individual; that of instinct, on the contrary, is at once external and general; and thus the subjectivity of reason, which seems at first

sight so fatal a defect, is abundantly compensated for by its inevitable effect in the uninterrupted expansion of true individuality in place of the collectivity of instinctive behavior—an individuality, still further, which ultimately forms the basis of personal freedom and of moral and legal responsibility.

At this stage, then, that dominance over the environment which has been already emphasized as the essential characteristic of all life assumes its highest form as the dominance, no longer of the body, but of pure mind, far-reaching in its extent and inexhaustible in its potentialities. For even the commonest activities of every civilized society are obviously governed not by instinct (in any literal sense) but by rationality. Its everday life presents a rapidly increasing scientific aspect, while its customs and conventions more and more embody great principles of law, ethics and religion. But, still more fundamentally, this dominance of mind finds both its ultimate basis and its clearest expression in that apprehension of the character equally of itself and of its world which constitutes knowledge—understanding—thought; and if to these we choose to add intuition, we must not ignore the indestructible unity between intuition and reason.[3] For until the mind knows, it cannot effectively act; it can only blindly strive, or recede once more to the lower level of animal instinct with which, unfortunately, intuition proper is too frequently confused.

Fundamentally, therefore, reasoned knowledge is the manifestation of the mind's ascendancy over the world which is both its origin and its abode; it is its prevision of the path along which it intends to travel—the anticipation of its future course in the light of all its assured experience. It is also true, of course, that action is based upon belief as well as upon knowledge; but every sane belief itself

[3] I have dealt in detail with this subject in *The Philosophic Basis of Moral Obligation*, Chap. XVI.

arises from some measure of knowledge which it endeavors to supplement and transcend; between knowledge and belief, in other words, there can exist no real severance nor opposition. For such antagonism can reign only between markedly different stages in the development of these two attitudes, not between the attitudes in themselves—between an old faith, *e. g.*, and new knowledge, or between two spheres of experience that have not yet become properly co-ordinated, as in the case of art on the one hand and science or morals on the other; in all such instances alike, however, the faith that is proclaimed must repose on some kind of knowledge which is regarded as unquestionable; whether this knowledge can establish its validity or not is quite another question which does not affect the principle here.

Thus the evolution of life finally becomes the dominance of pure mind; and its further advance is marked by two characteristics which develop correlatively—continuous expansion, and increased internal organization. For while its detailed contents grow in volume they at the same time acquire a higher degree of mutual interrelation so as to become more and more systematized under far-reaching principles and laws, until there finally arises the inner world of knowledge and thought inseparably connected with the outer world of sense-perception; and as I have already observed, this "inner world," from the psychological standpoint, is subjective; it exists either in the mind of the individual experient or in the general or collective mind.[4] But it would be a radical error to regard this subjectivity as its primary characteristic—much more as its fatal defect. For just as we found that it inevitably results in the development of free individuality, so it is paralleled by a real and still more fundamental objectivity; and

[4] I merely instance these alternatives without considering in what sense, if any, the collective mind is real.

although knowledge certainly exists within the mind, it nevertheless always applies to, or is concerned with, the actual external universe. It is the expression of the essential character of this universe—the revelation of the permanent interconnections that underlie those superficial processes manifested, alike in man and in the higher animals, to sense-perception. It cannot be objected that knowledge is full of errors—of faulty hypotheses and incomplete theories; for this is obviously to misunderstand the true character of knowledge, which only arises as errors are discarded and partial theories corrected; and the two features that have just been indicated as its basal characteristics—"continuous expansion and increased internal organization"—are simply the inevitable outcome of its advancing unity with real being. Nor again is it sufficient to describe knowledge as an instrument or a conceptual formula. Of course it is; but it is an instrument which more and more effectively maintains our contact with reality, and a formula that ever more fully and accurately expresses its character—a fact sufficiently established, surely, by the universal applicability of Einstein's highly abstruse mathematics.

It is only in the light of this long and tortuous evolution of the dominance of life, under its highest form as mind, that we can perceive the true value of two of the outstanding concepts of our day—the external world of Nature on the one hand, and the inner realm of Natural Law on the other; the first as revealed to sense-perception, and the second as the rapidly swelling content of modern knowledge; not, however, as separate but rather as indissolubly united. Excluding here aesthetic experience, the long series of changes in the meaning of the term "Nature" has at last culminated in its being employed, consciously or unconsciously, explicitly or implicitly, to denote objects and processes in the objective world that are actually understood

or, in principle though not in detail, are intelligible to human reason. But thus to say that Nature is intelligible means that its character can be expressed in terms of human thought; for until it can be so expressed it is not completely understood. Parallel to the outer world of Nature, therefore, there arises the inner realm of Natural Law as the mind's formulation of the interconnections of external reality.

The real character of this uninterrupted expansion can be appreciated only when it is regarded as the result of the mind's unceasing struggle to dominate its world; it is the transference to the psychical plane of life's earlier dominance over its physical and organic environment. Within the sphere of Nature mind is free to exert its proper powers, though it is not, of course, free to act merely at its own caprice; for mind itself falls under the sway of those natural laws which it discerns in its universe. But as Hegel and the ancient Greeks were fond of saying, mind is "at home with" Nature.[5] Only it is never content to stay at home; for although beyond the realm of Nature it is often baffled, it is never helpless; rather is it spurred onward to seek fresh triumphs—to found new colonies which may extend and strengthen the empire of knowledge.

But Nature has nowhere any final boundaries; everywhere it merges into that still wider sphere which man has always called the supernatural—the realm of powers regarded as either hostile or beneficent, according to the type of his religion. This inexhaustibility of Nature, again, inevitably reflects itself in the character of our knowledge of natural laws. It is not sufficient, however, to recognize that these laws must incessantly increase in number, while at the same time they become more intimately unified. For to this it must be added that natural law is unceasingly manifesting itself as more and more profound—intricate—

[5] Cf. Plato's οἰκείως ἔχειν πρὸς θεὸν—"at home with God."

complex—difficult to comprehend and equally difficult to express. These characteristics are obviously alike in the rapidly growing necessity for still further specialization, in the increasing applicability of mathematical methods to all branches of enquiry,[6] in the advancing complexity of mathematical investigation itself, and finally in the current search for the logical basis of the most elementary mathematical formulae. This last feature is perhaps the most significant of all; for it plainly shows that even the simplest possible truths really imply principles of baffling profundity, so that to regard them as justifiable assumptions is itself the most unjustified of all assumptions.

Thus the character of "Nature" is steadily altering; its earlier simplicity has vanished forever before the modern revelation of its unsuspected intricacy; and this again has necessitated a further advance in the level of mind; for to be "at home with" Nature it must constantly re-adapt itself to its expanding environment, like a child taken from a slum to a palace. "Nature," in other words, always implies something more and deeper than itself; and just as ordinary light is one with the ultra-violet radiations, so "Nature" is continuous at all its boundaries with ultra-nature; it is, in short, infinitely self-transcendent. But this inherent transcendence must not be interpreted as implying any breach of continuity; it must, on the contrary, be allied with an exhaustless capacity for self-revelation to finite mind. From the evolutionary standpoint, again, the human mind is the product of Nature; and the course of its further development is such that as it advances to higher and higher stages it increasingly manifests its unity with Nature.

But not with Nature only; for since Nature is continuous with Ultra-nature, the boundary between them is ever

[6] Most unexpectedly, perhaps, in current psychology and in dealing with the phenomena of sex determination.

moving forwards so that what, at any given stage of thought, is ultranatural, becomes for the next higher stage wholly natural. Although therefore we are absolutely debarred from forecasting the detailed character of Ultra-nature, we can at least be certain that it will be intelligible to a more advanced type of mind and, further, that it will dispel the difficulties which baffle the lower understanding. But a still more important implication may now be discerned. For we have seen that the advance of mind really means its increasing dominance within its natural world; and that point where this dominance for the moment ceases marks the beginning of the ultra-natural. This point, however, is never fixed but is ever moving onwards; and this plainly means that the ultra-natural is the sphere where reign the highest forms of mind. To separate mind from Nature, therefore, and much more to oppose them to each other, is simply to cherish a false antithesis. For Nature is but the partial revelation of an infinite Ultra-nature; and this, again, is the dwelling place of infinite mind.

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GRAVITATION: A SIMPLIFIED THEORY OF RELATIVITY

GRAVITATION has long furnished one of the most perplexing and fascinating problems of physical science. "A large and valuable system of thought has been built up—mainly during the last hundred years—in which radiation and gravitation are completely independent. Radiation submits to analysis and invites correlation with other physical phenomena; gravitation stands inaccessibly apart. The complex organism of electro-magnetism, embracing as it does radiation, the aether, electricity, magnetism, the atom—even inertia (for radiation possesses inertia)—seems capable of assimilating the whole of physics—except gravitation. Matter appears to be the source of two streams of phenomena, one summarized in electromagnetism and the other in gravitation, and between them is a great gulf fixed. The completeness of the duality lies, of course, only in the conceptions. Experimental evidence of a bridge across the gulf might have arisen at any time."[1] In recent years, Einstein has made a most valuable and far-reaching contribution to the problem of harmonizing this duality of conception. There would appear, however, to be an even simpler method of expressing his solution of the problem than that adopted by Einstein himself, and one which does not involve such difficult theoretical conceptions.

[1] "The Deflection of Light in a Gravitational Field," by Herbert Dingle, in *Nature*, Vol. 110, p. 390.

"From the time of Newton until quite recently, gravitation has been looked upon as an essential property of matter—as characteristic as the property of inertia. Whenever we find matter showing the unmistakable effects of inertia, we find also evidence of gravitational influence. The universality of these twin phenomena has so impressed physicists that they have come to look upon them as the fundamental properties of matter. Matter is, by definition, that which has inertia and exerts gravitational attraction." [2] In other words it is a matter of observation that every body of "matter" in the physical universe not only exercises its own inertial influence but also its own gravitational influence. It "pulls" other bodies towards itself, or causes them to exhibit a tendency to "fall" towards itself. This gravitational influence or "pull" is a force of quite definite intensity for each unit of matter. It is in direct ratio to the mass of the unit. It decreases in intensity, however, with increasing distance from the unit, according to a definite ratio—inversely to the square of the distance. The result is that other bodies, if they are left to themselves and are not influenced by any other force, fall towards the "pulling" body in a straight line and at a definite, constantly accelerating, velocity relatively to it. If there are other bodies of matter also in the neighborhood, however, each exercises a similar "pull" on any individual body. The relative intensity of each "pull" thus depends on the relative distances of each body which is being pulled and on the relative masses of the pulling bodies. Assuming that the "pulling" bodies are stationary relatively to each other and that the body which is influenced by their "pulls" is not affected by any other force or influence, it will move along a definite line and at a definite, constantly accelerating, velocity relatively to them all, both the line

[2] "The Deflection of Light in a Gravitational Field," by Herbert Dingle, in *Nature*, Vol. 110, p. 390.

and the velocity being determined by the balance of these respective rival "pulls." If the pulling bodies are moving relatively to each other, or if the pulled body is influenced by any other force in addition to their "pulls," its path will be modified accordingly, but in a perfectly definite manner.

Now, a positive force which operates in this definite manner implies the existence of a negative counterpart. If there were no negative, or counter, influence at work the force of the "pull," however slight, would cause the two bodies to "fall" together with an infinite velocity—instantaneously. The fact that the velocity of the "fall" is definite—finite—implies the operation of some restraining influence which operates with an equally definite intensity counter to the "pull," so that the "falling" body moves with this definite velocity, neither more nor less—the mean between the two influences. Similarly the fact that the path of the "fall" is straight relatively to the "pulling" body, and that the falling body tends to cling to this straight path with a definite intensity notwithstanding any other influence which tends to make it deviate from this path, implies the existence of some influence restraining its path to this definitely straight conformation relatively to the "pulling" body. This counterpart of the gravitational "pull" is called the *gravitational inertia* of the "pulling" body; which must not be confused with what has usually been called its *inertia* proper, or absolute inertia, which will be referred to later. Gravitational inertia gives the tendency to "fall" this definite intensity, and this definite velocity, and this straightness of direction, relatively to the pulling body, in competition with all rival influences. In other words it operates to cause the two bodies to tend to maintain their positions—their geometrical relations—relatively to each other, so that the "falling" body tends to follow the "pulling" body in that body's motions relatively to other things and to maintain this definite velocity and direction rela-

tively to it notwithstanding the "pulling" body's motion relatively to other things. The earth's gravitational inertia, for instance, makes a falling stone conform to the earth's motion "through space" while it falls. It also causes all the paraphernalia of our every-day world to maintain their positions relatively to the earth—to remain at rest relatively to the Earth or, if motion be imparted to them by any force, to continue to move (by momentum) in a straight line and at a uniform velocity relatively to the earth—apart from the curves and accelerations caused by the earth's specific gravitational "pull," atmospheric resistance, *et cetera*. Gravitational inertia is, in fact, just gravitation considered apart from its specific "pull." If its specific "pull" be left out of account, a gravitational field may thus be considered as a field of gravitational inertia. Every body—indeed, every entity, even radiation—has thus its own field of gravitational inertia. The relative intensity of this field also depends on the same factors as those which determine that of its gravitational field, namely the mass and the distance of the entity with which it is associated. Similar considerations, of course, apply equally to every exhibition of any form of force, or radiation. Each has its inertial counterpart—its inertial field, coinciding geometrically with its field of force.

The consequence of this gravitational-inertial property of matter is that the position and motion "in space" of every body is definitely influenced by the gravitational inertia of every body in the universe according to the mass and the distance and motion of each body. The Galileo-Newton system of mechanics which held the field undisputed for about two hundred years prior to Einstein postulated that, in addition to these influences of gravitational inertia, "space" itself must be assumed to exercise a similar inertial influence. This was what was regarded as *inertia*, properly so-called, without any qualifying adjective—abso-

lute inertia. But it was assumed to operate with a uniform intensity throughout its field of force and without any "pull" towards any point in it. It was assumed to operate so as to cause all bodies to tend in direct ratio to their mass, to maintain their positions relatively to "space"—to remain "at rest" or, if already moving, to continue to move (by momentum) in a straight line and at a uniform velocity relatively to "space." The inertial path of any body was thus conceived as being determined by the combination of (1) the actually observed gravitational-inertial influences of every body in the universe, and (2) this assumed inertial influence of "space." As the constitution of matter is electromagnetic, the "bodies" thus influenced included every known physical entity (except, of course, gravitation and "space" itself) including radiations, such as light. This inertial influence of space had never actually been observed. It was merely an hypothesis—an hypothesis which was generally thought to be necessary on metaphysical grounds. As a working hypothesis it justified itself thoroughly. It answered with sufficient accuracy for all the purposes of science for about two hundred years. But comparatively recently the experiments of Michelson and Morley on the propagation of light disclosed a limit to its validity. Certain of the phenomena of light-propagation apparently could not be explained on that hypothesis. The theory of the Galileo-Newton system of mechanics was thrown open to doubt.

Einstein attacked the whole problem afresh. He did not question the assumed necessity of some "space" possessing the property of inertial influence, nor that that inertial influence should be uniform throughout it. He tacitly assumed such a necessity. His method instead was to disregard the first series of factors mentioned above—the gravitational-inertial influences of physical bodies — as actual properties of matter, and to regard them instead as

properties of space—as the *only* inertial properties of space, or rather as disclosing—as due to—the geometrical properties of space. He conceived the inertial influence of space as being uniform throughout space, but space itself as being geometrically contorted and curved in just such a manner as to produce those apparent variations of its inertial influence. This involved a similar mathematical contortion of *time* also. The conception of the uniformity of the inertial influence of "space" involved, as we have noted, that a body whose motion is regulated by spatial inertia alone moves at a uniform velocity relatively to "space." But when bodies of matter are in motion, along with their gravitational-inertial fields, their moving inertial influences cause actually observed variations, or accelerations, in the velocities of the motions of other neighboring bodies. The moon, for instance, follows the earth owing to the earth's gravitational-inertial influence, and thus moves "through space," while it is circling round the earth, with a spiral motion, and hence with constantly changing velocity relatively to "space" (or to other bodies), instead of moving in a straight line and with a uniform velocity, or in a simple curve owing to the earth's gravitational "pull." In order to reconcile this non-uniformity—this acceleration—of observed inertial velocity with the assumed uniformity of the inertial influence of "space" (the *only* inertial influence according to Einstein's theory), time must also be similarly contorted mathematically.

These geometrical contortions and curvatures of space and time are somewhat difficult conceptions for people who are not familiar with the higher reaches of pure mathematics, but to the mathematician they present no difficulties. They merely involve the introduction of an additional dimension beyond the three postulated by the Euclidean system of geometry (the geometry of actual observation), and an additional factor in the time-element. The

effect on *theory* is that, in place of the homogeneous space-time of the Galileo-Newton system of mechanics Einstein's theory postulates a heterogeneous space-time corresponding with the actually observed effects of the gravitational-inertial fields associated with bodies of matter. It thus involves the conceptions of the variation of the real values of distances and times according to the relative motions of bodies of matter in order to reconcile the observed heterogeneity of the inertial influences of the physical universe with the assumed uniformity of the inertial influence of "space." The *practical* result of the theory, however, is to eliminate from our conceptions of the inertial influences of the universe the second factor mentioned above—the assumed inertial influence of "space"—and to take account only of the first series of factors—the actually observed gravitational-inertial influences of bodies of matter. This enables any convenient unit of matter to be utilized as the reference-frame for the kinematical and mechanical phenomena of the whole universe. A perfect kinematical and mechanical relativity is established between the positions and motions of all bodies without any need to take account of "space." Any body is equally valid as a reference-frame for this purpose. The kinematical and mechanical laws of the universe may be stated in a perfectly general form which is equally valid for any such reference-frame.

To the gravitational-inertial influence of such bodies there must, of course, be added in practice the observed gravitational "pull" of each gravitational-inertial field. But, as these observed fields are no longer, in Einstein's theory, properties of the bodies with which they are associated, but are due to the geometrical properties of "space," their specific gravitational "pulls" must also, theoretically, be due to the geometrical properties of "space"; and thus the duality between the conceptions of gravitation and of

other phenomena disappears. This, however, only affects *theory*. It is of no *practical* consequence.

This method of interpreting the mechanical phenomena of the universe was seen immediately to lead to certain practical consequences which could be tested by actual observation. In the first place, it exactly accounted for the observations as to light-propagation made by Michelson and Morley. Indeed, it was the rigid mathematical application of these observations to this conception of "space" as possessing inertial influence, and a uniform one, which led Einstein to the first step in the evolution of his theory —to his "special" or "restricted" theory of relativity. The formulation of his generalized theory was, for Einstein, a natural if technically difficult evolution from his more restricted theory. Its other main practical consequences which can be tested by actual observation may be best illustrated by its effects on the deflection of light by a gravitational field. Under the Galileo-Newton system, if a body of matter or (assuming the electro-magnetic theory of matter) a ray of light were moving by its own momentum (or radial force) "through space," then, when it passed sufficiently near to any other body for the gravitational influence of that other body to be appreciable, its path would be subject to two rival influences besides its own momentum (or radial force). It would, on the one hand, be held in the grip of the inertial influence of "space," tending to hold it on a straight course and at a uniform velocity relatively to "space," and, on the other hand, it would be pulled off that course by the gravitational "pull" of the gravitational-inertial field of that other body. Its path would thus be a curve representing the mean between the effects of those two rival influences. In Einstein's method of interpretation, however, this "grip" of "space" is eliminated, and the "pull" of the gravitational-inertial field operates alone, free from any interference. It is of no consequence

for practical purposes that, in theory, this "pull" is now the "grip" of spatial inertia instead of a property of the "pulling" body. The practical result is that the path of the body or the ray of light is no longer a curve which is the mean between the effects of the gravitational "pull" and the spatial "grip," but is a curve which represents the full effect of the gravitational "pull" of the body which it is passing—which, of course, includes the special grip of that body's own gravitational-inertial field. In other words, the curvature of its path would be approximately doubled. The now famous observations in regard to the deflection of the rays of light from stars by the gravitational influence of the Sun, made during the eclipse of May, 1919, conformed with a high degree of accuracy to what would have been required according to this theory of Einstein's. The amount of deflection was approximately double what would have been expected according to the Galileo-Newton system. Einstein's theory was thus shown to be a conception which gave a much more faithful picture of the actual facts of observation than the Galileo-Newton theory. It was also found to explain a hitherto unexplained phenomenon in the path which the planet Mercury describes round the Sun. It will suffice here, however, to say that this phenomenon in the perihelion of Mercury is explained by exactly the same difference in the method of interpreting the effects of inertia—by the elimination in practice of the previously assumed "grip" of "space."

Now, we had occasion to mention earlier that the ascription of inertial influence to "space" was an assumption—an hypothesis. It is even more of an assumption than at first sight appears. No inertial influence has ever actually been observed to exist which is not the counterpart of some positive force—of gravitation or of some radiation. Again, no inertial force has ever been actually observed to exist which is of uniform intensity throughout its field of influence, or

which does not vary in intensity according to the law of the inverse square of the distance from some point of origin. No such inertial influences have ever been actually observed as physical properties. The classical hypothesis as to a "space" which possesses a uniformly distributed inertial influence without any counterpart of positive force involves a double assumption therefore. It assumes the existence of a particular inertial influence which has never been observed to exist, and it assumes for it a variety and form of inertial influence which have never been observed to exist as physical properties. It is somewhat difficult to devise a short term to denote this particular theory of space, but the term "semi-physical space" seems convenient and not inappropriate, since the hypothesis ascribes actual physical properties to its "space," but in a form which has never been actually observed to exist as a physical property. The term is adopted, however, purely for the sake of brevity. It must not be supposed that it implies any adverse criticism of the hypothesis.

It is not the function of this article to examine the metaphysical grounds which are sometimes supposed to support this "semi-physical" theory of space. It must suffice to say that they are at least of doubtful metaphysical validity. To a very large extent, however, the hypothesis has simply been unconsciously assumed. This is probably due to a habit of thought which is unconsciously developed owing to the habit, and practical necessity, of deliniating our geometrical conceptions on paper or some other physical medium. We thus early acquire the habit of visualizing all objects as supported by some such continuous, uniform, independent physical medium. It is difficult to remember that as a rule the page is in reality no part of the geometrical conception which is depicted on it. For a true appreciation of the geometrical conceptions or phenomena depicted, the page must usually be conceived as non-existent,

and the relations between disconnected parts of the figures must be sought in some other conception.

There seems no fundamental objection, therefore, to dropping, tentatively, the assumption of any "semi-physical" space. We thus approach the whole matter afresh from a new direction, adopting the reverse method of interpreting the observed phenomena to that adopted by Einstein. Following this method, the second of the factors referred to above — this assumed inertial influence of "space"—is ignored, and account is taken only of the first series of factors, namely the actually observed gravitational inertial influences of units of matter. "Space" itself, conceived as an actual physical entity possessing the physical property of inertial influence—semi-physical space—is thus ignored. No assumptions are made about it at all. It is neither assumed that it does, nor that it does not, exist. Future investigations may quite conceivably disclose the existence of some phenomenon more or less corresponding to it. Meantime no phenomena have been observed which afford any evidence of the existence of any such semi-physical space, and it is found to be much simpler to interpret the actually observed phenomena unhampered by any preoccupations with an assumption that it does exist; and all the known observed phenomena of the physical universe can be adequately explained on this basis of interpretation. For *practical* purposes, indeed, this scheme is in essence the same as Einstein's, though it is much easier to "visualize," and therefore easier to apply. Einstein's theory is extraordinarily difficult to visualize owing to "space" being made the basis of his scheme. It is almost impossible for any but very highly skilled mathematicians to acquire a proper mental grasp of the conceptions involved. The visualization of his scheme becomes enmeshed in mathematical complications. When the assumed semi-physical space is ignored, and the actually observed gravitational-

inertial fields associated with actual units of matter are made the basis of a scheme, it becomes possible to move among the kinematical and mechanical phenomena of the physical universe with a freedom of conception which is almost surprising. Einstein interpreted the Michelson-Morley experiments as indicating that by no known means can we detect our motion through (semi-physical) space. When the existence of any such "space" is not postulated as a necessity, however, the Michelson-Morley experiments (so far as they are conclusive) may equally be interpreted as indicating that in fact no such "space" does exist; that space exercises no inertial influence. The way is then clear to start from any known unit of matter, along with its observed gravitational-inertial field, and to build up synthetically a scheme of the kinematical and mechanical system of the universe.

In regard to *theory,* however, the two methods are fundamentally different. In the new theory "space" is no longer conceived as an actual physical entity possessing an actual physical property of inertia—exercising an actual inertial influence—as it is in both the Galileo-Newton theory and in Einstein's theory. It becomes at most a merely imaginary reference-frame, devoid of all actual influence, which may be utilized in conception or not according to convenience; and one which, if used at all, may with perfect validity and convenience be conceived in an ordinary Euclidian three-dimensional form. There seems little advantage or convenience, however, in making use of any such conception at all. Any unit of matter, or any definite system of units, makes a much more convenient reference-frame. The problem of the kinematical and mechanical relations between the units composing the physical universe, too—the formulation of a theory of their relativity—becomes divested of all the non-Euclidian mathematical complications involved in the conception of an all-pervad-

ing "space" exercising an actual, uniform, and equally intense inertial influence. A complete and simple relativity is established in ordinary Euclidian form. The kinematical and mechanical phenomena of each and all the bodies of matter or units of radiation in the universe are conceived as being entirely free from all kinematical or mechanical control or influence except that of each on all. The whole body of conceptions embracing the variance of the real values of distances and times is dispensed with. Theory maintains the same forms as actual observation. Time and distance may with perfect validity be taken as being of identical values in all places and under all circumstances—the values of actual observation. Euclidian geometry is restored to its place as the standard of relativity; and "the man in the street" may once more understand it.

When this new method of interpretation is applied to the actually observed phenomena of our physical universe it is found immediately and simply to agree with, and to explain, all those phenomena which Einstein's theory explained. We need not digress here to demonstrate this more fully as the matter should be clear from what has gone before. Let us now follow up some of the logical consequences of this method of interpretation. Each atom has its own gravitational-inertial field. For simplicity we will now call these fields merely "inertial fields," since, in this method of interpretation, these inertial counterparts of specific forces, or radiations, are the only inertial fields to be reckoned with in the present state of our knowledge. Each electron composing these atoms has also its own inertial field—the inertial field implied by the existence of its radiational force; but we will have something more to say about this later. These electrons are, according to the now generally accepted atomic theories, revolving in orbits round other nuclear electrons (and therefore also rotating, either in relation to their nuclei or to other electrons) at a

velocity approximating to that of light-transmission. Their inertial fields are all consequently rotating similarly, with an equal velocity, and with a slightly vibratory motion owing to the orbital motion of the electrons with which they are associated. The inertial field of any body of matter, such as the earth, is in consequence not a simple unit. It is a highly complex one. It is composed of an almost inconceivably enormous number of subsidiary inertial fields —those of the electrons composing all the atoms of which the earth is formed—rotating and vibrating with a velocity similar to that of light. These inertial fields, of course, have no actual boundaries. They theoretically extend *ad infinitum* outward from their cores of matter, though with intensity decreasing inversely according to the square of the distance from their cores. The field of force of an electron, and consequently its inertial field also, is of relatively infinitesimal intensity and extent; but *in cumulo* they become enormously powerful and extended. It is the *cumulo* influence of all the electrons which compose the atoms forming the earth's structure, for instance, which constitutes the gravitational field, and the inertial field, of the earth. Every other body in the universe has a similar complex inertial field. The whole universe of inter-stellar space (and of matter also) is thus filled with an enormously complex common inertial field of infinitesimally fine grain or texture composed of an almost infinite number of these subsidiary inertial fields rotating and vibrating with a velocity approximating to that of light-propagation. Now this, it may be noted in passing, is exactly the kinematical condition of the "aether" postulated by the *kinetic* or rotational theory which Lord Kelvin laid down as required to account for the very high degree of rigidity and yet of elasticity which the "aether" must possess in order to bind the universe together and yet, for instance, to transmit light-waves. And, of course, these inertial fields would deter-

mine the paths and the velocities of light and of all other radiations no less than those of bodies of "solid" matter; and it is only by the propagation of radiations that the "aether" can be observed. It is, in fact, merely a conception to account for the mechanism of the transmission of force or radiations through apparently empty space. The form—the kinematical phenomena—of the "aether" thus necessarily conforms exactly to the form of the inertial influences operative in "empty space." If it is considered necessary to postulate the existence of an aether which is an actual physical substance, its form would thus be determined by the mean of the influences of all those rival subsidiary inertial fields. It would itself be merely attenuated, diffuse, energy, soft and compressible, held in position by the powerful grip of the mean of these inertial influences, and vibrating in consequence with an infinitesimally finely-grained motion, and changing its form or shape constantly with the motions of the bodies of matter with which the various inertial fields are associated. For present purposes, however,—that is for purely kinematical purposes—it is not necessary to take account of the "substance" of the aether. Indeed, it is possibly unnecessary to postulate any other substance for it than the almost infinitely complex, fine-grained structure of the common complex inertial field of the physical universe. In any case it now appears to become clear both how the "aether" acquires this rigidity and elasticity and why the motions of bodies of matter through it cause no appreciable disturbance of it. But our main concern at present is with gravitation.

In a complex structure such as that of the earth the myriad electrons composing its material substance will, apart from their proper orbital motions, be rotating in every conceivable direction relatively to each other. Their inertial fields will be similarly rotating. It is not possible in the limits of this article, and without diagrams, to indi-

cate the effects of this in detail; but let us take one of the simplest cases. Let us suppose the case of one single electron, along with its inertial field, alone in the universe. Let us suppose it possessed of radiational energy only, and as being devoid of any gravitational "pull"; and let us view its inertial field as being simply the counterpart of its radiation; but let us leave out of account any "pulling" tendency in this counterpart in any direction. Let us consider it as being simply a field of true inertia relatively to the electron, but, of course, a property of the electron itself. Now suppose some other entity, x, which for the sake of simplicity in studying the problem is supposed itself to be devoid of mass and therefore of any inertial influence of its own. Suppose x to be in the neighborhood of the electron. Then the inertial field of the electron will hold x fixed in a stationary position relatively to the electron, there being no force supposed which could impart motion to it. Suppose, now, another electron, of similar mass, but so far removed that its field can exercise no appreciable influence on the first electron or its satellite x. Now, if for any reason the first electron should commence to rotate on its own axis relatively to the second electron, its satellite x, being fixed and stationary relatively to the first electron, held so in the grip of its inertial field, would similarly rotate along with it. Relatively to the second electron, inertia would no longer cause x to remain at rest; inertia would have become a motive force, causing it to rotate in an orbit.

Now, suppose the second electron to be brought so close to the first that its inertial field became an effective influence all around the first electron; and suppose the second electron also to be rotating on its own axis relatively to the first electron but in the exactly opposite direction. Before the satellite x had completed one revolution it would have come under the strongly effective influence of the inertial field of the second electron. It would no longer

rotate in perfect unison with the first electron. There would now be a powerful inertial influence operative on it tending to make it remain at rest relatively to the second electron no less than to the first; that is to say tending to make it describe an entirely different orbit in no way coinciding with its original orbit, and in a reverse rotary direction. The satellite x would now be controlled by the mean of those two influences. The full effect could only be shown by a diagram, but even without one it can readily be perceived that the general effect would be that x would find itself caught in a vortex-effect which would draw it in between the two electrons and then shoot it far out, approximately along the straight line running straight through mid-way between them. It would theoretically, assuming it to have no bulk, continue to travel along that line with ever decreasing velocity *ad infinitum*. Now this evolution of x, be it observed, is not "motion," caused by some "force," as these terms are normally used. It is, under those conditions, the inertial "state of rest" for x. It is what happens to x supposing that there is no force or influence affecting it except inertia—the inertial influence of the two rotating electrons. The most important thing to know, however, for our present purposes, is that the main general feature of the common complex inertial field of the two rotating electrons is that it no longer tends to hold any body at rest relatively to either of the electrons. It now tends to cause all bodies to *move* relatively to both electrons, and to move inwards nearer to both, and nearer to the point mid-way between them in the first instance.

It would be a tedious and difficult task to attempt to explain in mere words the effects of all the other possible variations of the relative rotations of the two electrons. It must suffice here to say that the predominant effect will apparently be to cause motion of any body held in the grip of their common complex inertial field, and motion in a

form which takes them constantly into a mean position which is nearer to both electrons than that which they would occupy if the inertial field of one only influenced them. This is chiefly due to the fact that the tendency of a simple inertial field—as distinct from a complex one—is to cause the motion of bodies to conform to lines which are not always straight lines relatively to the field, but which in their simplest forms are radii from the nucleus of the field and circles round it. The effect of simple inertial fields is to cause other bodies to maintain their *position* relatively to the nucleus of the field. This position is composed of *distance* and *direction* from the nucleus. Direction is not altered by motion along a radius, and distance is not changed by motion along a circumscribed circle. Uniform motion relatively to the nucleus, therefore, is that which deviates uniformly from the lines which would be a radius and a circle round the nucleus respectively. A straight line, other than a radius, would form a path of constantly accelerating motion relatively to the nucleus. A tangent, for instance, would start from a radius as a path consisting of the *maximum* possible amount of change of direction but *zero* amount of change of distance; but eventually it would become one of almost *zero* amount of change of direction and almost the *maximum* possible amount of change of distance, in any given unit of time. In other words, if the motion along the tangent was of uniform velocity relatively to the tangent itself, it would be a constantly accelerating velocity relatively to the nucleus of the inertial field. A body in motion, therefore, directly across a radius from the nucleus of any simple inertial field would tend to be held by the inertial influence of the field on a path which would be a circle or orbit round the nucleus at a uniform velocity.

If all the various effects of the different possible forms of mutual rotation of inertial fields be superimposed on each

other so as to be operative simultaneously in the same area, or common complex field, the net effect will be to cause all bodies to move constantly inwards towards a common center in the system. In other words, the rotations of the inertial fields of the electrons composing any system create a gravitational "pull." They transform their common inertial field into a gravitational field. Now these, of course, are precisely the conditions existing, according to presently accepted atomic theories, in the structure and in the field surrounding the structure, of any body of matter. This method of interpreting the observed phenomena, therefore, throws at least some suggestive light on the nature and cause of gravitation. It also effectually bridges the duality of conception between gravitation and the other phenomena of the physical world. Inertia not only becomes the counterpart of gravitation, as it does in Einstein's theory, but gravitation becomes merely the particular form which is imposed upon inertia by the purely mechanical effect of the structure and internal mechanism of the atom.

It is worth noting that none of these subsidiary gravitational effects caused by the various forms of relative rotation are circular in their distribution; and in most cases the configuration is itself also rotating on an axis relatively to the system as a whole; and again the axis has also a rotatory, or orbital, motion of its own. The net effect of this would be to greatly increase the fine vibratory effect present in the common complex inertial field, and more especially to strengthen and refine the "texture" of the gravitational "pull" by making it more complex.

The matter would be left incomplete, however, if we failed to take further notice of that shooting-out effect which was noticed in the case of oppositely rotating inertial fields. This might be supposed, at first sight, to counterbalance the gravitational effect; but this is not so. This shooting-out effect, though powerful, is concentrated along

a narrow line. It is like a concentrated spear-thrust, much more powerful at the point where it operates than the contrary gravitational impulse, and it consequently breaks through that impulse by the sheer weight of its concentration at that point. In any system of electrons constituting a body of matter these spear-thrusts of inertial influence keep constantly changing in direction. Some of them keep constantly rotating round a complete circle, owing to the orbits described round each other, relatively to the system as a whole, by the electrons which give rise to them. The *axis* of their rotation has an orbital motion also. Some of these spear-thrusts are rotating in one direction and some in another, but none ever in a directly opposite or in a coinciding orbit. They will thus keep constantly intersecting each other, and where they intersect there will be a powerful concentration of inertial influence propelled, along with the point of intersection, at enormous, constantly accelerating velocity, along a certain curve. There will thus be a small but violent disturbance of the equilibrium of the common complex inertial field in a certain direction. There would be an almost infinite range in the velocities of these thrusts and in the frequency of their repetitions. And thus we would have "radiation" in various forms, composed of *"quanta,"* if not of "waves," of energy. So that here, again, we have a suggestion as to the cause of radiation.

At this point, however, a difficulty suggests itself. This whole theory of gravitation is based upon the inertial field which is implied by the radiational force emanating from an individual electron—or whatever the ultimate unit of matter may be. If radiation is caused by the mutual rotations of electrons, how can an individual electron emit any radiational force? In the first place, it must be observed that the "radiational force" required is not necessarily a radiation in "wave" form, or in *"quanta"*; nor is it even necessarily an emission at all. A field of pure inertia alone

would suffice. Now, assume a single, indivisible, ultimate unit—a point—alone in infinite space—the only entity in otherwise infinite, incohate, universality. It would itself be a universal, of infinite dimensions, because there would be no other finite entity with which to compare it and so to ascribe limits or dimensions to it. (There would, indeed, be no-one to make the comparison.) Now assume a second such "point." It also, apart from the first point, would be a universal; but now it has become possible to compare the two points. To that extent they have both become finite. If we make a geometrical comparison, their *dimensions* are now finite. They can be defined in terms of their relative sizes. If a third point be now added their geometrical relations can be completely defined—their *distances* and *directions* from each other—their *positions*—as well as their sizes. Now, if these units in fact maintain their individuality—their independence of position—and do not merely fall into and absorb each other or relapse into a common universality or infinity, that very fact implies the existence of some "force" which enables them thus to be disintegrated from each other and from mere universality or infinity or "void." In other words, it implies some force which tends definitely to maintain their positions—some inertial force. Consequently the mere fact that electrons do maintain their individuality in spite of their complex motions implies the existence of an *inertial* force, at any rate, definitely associated with each; and that is all that is required for this theory of gravitation. Indeed, while this theory cannot, of course, offer any explanation of the cause of the motions of electrons, it rather suggests the query whether an electron (or the ultimate geometrical unit of matter, whatever it may be) is in reality anything more than the center of an inertial field.

Inertial fields, themselves, as we have noted, theoretically extend *ad infinitum* but with constantly decreasing

intensity. This again is merely another way of saying that they, too, are mere disintegrations from an infinite, universal, incohate energy, gathered up or focused into a formation which becomes finite only by the graduation of its intensity, or disintegration from mere universality, and by its comparison with other entities. The finiteness of all these entities is, in reality, in every case, merely relative. Whatever their masses or their intensities, electrons and inertial fields alike must have an essential *residuum* of mere universality—a tendency to relapse into mere incohate infinity—to cohere. This would explain why the "aether," if it consists of some form of diffuse, suspended energy apart from the inertial field of the universe itself, would tend to cohere into one continuous whole while it remained sufficiently flexible and compressible to conform to the shifting mean influences of all the subsidiary inertial fields composing the common complex inertial field of the universe.

While this article is primarily concerned with gravitation, and consequently much else that is suggested by this method of interpretation must be passed over, it would be incomplete without a reference to another series of conclusions which are suggested by the inertial effects of the mutual rotations of electrons which we have roughly sketched. It will have been observed that the effects of such rotations are in reality to cause various forms of *strain* in the common complex inertial fields of the systems concerned. The influence of these strains will extend over the whole common field with decreasing intensity at increasing distances from the area of their formation. The strains will always tend to cause, or perhaps it would be more accurate to say to modify, *motion*. A study of these strains and of their effects on the internal mechanism of the units of matter in which they arise—for it is a mechanism—and on the field surrounding them and on the mech-

anism of neighboring units, opens up a whole fascinating chapter which suggests, among other things, interesting explanations of the induction of different forms of radiation, of the formation of magnetic fields, and of the phenomena of momentum. There are other chapters too which seem to be opened up with comparative ease by this method of enquiry which cannot even be referred to in the limits of this article; but enough has been said to suggest the pregnant possibilities of this method.

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STORNOWAY, SCOTLAND.

MECHANISM AND VITALISM

A CRITICISM OF LOEB'S "REGENERATION"

THE attitude toward vitalism that largely prevails at the present day among men of science has been well expressed by Haldane, the well-known English physiologist. "Actual investigators," he writes, "have preferred to avoid vitalism so far as they could as the vitalistic hypothesis seemed to set a limit to experimental investigation as they rightly and instinctively felt that there is no such limit." [1] The view taken by a number of eminent men in the field of natural science may be summarized as follows: the vital principle postulated by the Vitalists can not be reconciled with the demands of science for quantitative measurements; it serves no purpose but to hinder the progress of science. Tigerstedt, the physiologist, lays down the principle of the conservation of energy as a fundamental concept in physiology, and immediately adds that "on account of this concept of animate nature and the forces occurring within it, physiology has divorced itself once and for all from Vitalism, with its capriciously changing spectre, vital energy, that is subject to no laws, at one time inconceivably effectual, at another vanishing without a trace." [2] Verworn, another eminent physiologist, complains that the concept of vital energy is always hazy, and, at

[1] Haldane, J. S., *The Organism and Environment as Illustrated by the Physiology of Breathing*, N. Y., 1917, p. 17.

[2] Tigerstedt, R., *Lehrbuch der Physiologie des Menschem*, Leipzig, 1923, p. 2.

most, serves only as a principle of convenience (Bequemlihkeitprinzip). This obscurity of a mystical unknown vital energy, he says, renders impossible its exact comprehension.[3]

The phenomena of mental life are also included in the mechanistic interpretation. "I shall mention," writes Doctor Crile,[4] of the Northwestern Reserve, "not that man is in *large measure* the product of his environment, but that environment has been the actual creator of man; that the old division between body, soul, and spirit, is non-existent; that man is a unified mechanism responding in every part to the adequate stimuli given it from without by the environment of the past, the record of which is stored in part in cells throughout the mechanism, but especially its central battery—the brain."

Behaviorism is a striking illustration[5] of the extent to which Psychology has come under the influence of a mechanistic philosophy. Mechanism, however, is not confined to the expressed Behaviorists. Doctor Warren,[6] Professor of Psychology at Princeton University tells us that "in biology the complex of *life* is still hypostasized by the Vitalists. Similarly in the domain of mental phenomena *will, thought* and *personality* are hypostasized by certain psychologists as determiners of activity. The underlying assumption of a 'personal agency' may prove correct in one form or another. But the trend of scientific progress is all in the other direction. As our knowledge of natural phenomena advances these personal agencies are one by one resolved into physical and chemical operations of the phenomena themselves. The evidence today seems clearly to favor the Mechanistic interpretation as a

[3] Verworn, M., *Allgemeine Physiologie*, Jena, 1909, pp. 52 and 53.

[4] Crile, George W., *The Origin and Nature of the Emotions*, N. Y., 1915, p. 128.

[5] Cf. Watson, J., *Behavior, An Introduction to Comparative Psychology*, N. Y., 1914.

[6] Warren, H. C., *Human Psychology*, N. Y., 1919, pp. 433-434.

working hypothesis in psychology as in other fields of science."

One of the most recent contributions to mechanistic thought is a posthumous volume of Dr. Jacques Loeb, who, until his death was associated with the Rockefeller Institute for Medical Research. Loeb, as it is well-known, had been for years an ardent defender of Mechanism.[7] The thesis of the present book is found in the preface: "It was generally or frequently observed that the development of the mutilated egg resulted in the formation of a normal organism. Driesch maintained that this phenomenon could not be adequately explained on a purely physico-chemical basis, but that in addition a metaphysical guiding principle inherent in the organism as a whole was to be postulated." On account of the many factors involved in Driesch's experiments, Loeb maintains, these studies were too complicated to admit of mathematical (i. e., scientific) observations. Loeb's experiments, on the other hand, although dealing fundamentally with the same problem of regeneration, are of a simpler type and give quantitative determinations. From these experiments the author is led to the conclusion that "the process of regeneration was thus revealed as a purely physico-chemical phenomenon, leaving no necessity nor room for the postulation of a guiding principle aside from the purely physico-chemical forces."

The experiments were made on leaves of *Byrophillum calycinum,* the plant having been originally obtained some years previous by the author in Bermuda. Briefly, the experiments were as follows: Leaves were detached from their stems and suspended in air or so arranged as to dip partly in water. Both shoots and roots developed (the former growing upward, the latter downward) from the notches which occur at intervals around the edge of the

[7] Cf. Loeb, J., *The Mechanistic Conception of Life,* Chicago and Cambridge Univ. Press, 1912.

leaf suspended in water. The following observations were made:

1. It was not necessary to "wound" the leaf by cutting or injuring it on its surface in order for the shoots and roots to develop from the notches. It sufficed that the leaf be detached from the stem. Normally the sap flows from the leaf into the stem where it is distributed for the nutriment of the stem, shoots, and roots of the plant. When the leaf is detached and the sap can no longer flow into the stem, it goes to the notches, whence roots and shoots are produced.

2. Others things being equal, the force of gravity draws the sap down to the lower edge of the leaf; growth of the roots and shoots occurs for the most part, if not exclusively, on the lower edge of the leaf.

3. The sap of the leaf has the tendency to flow toward the shoots and leaves that grow most rapidly.

4. Equal masses of isolated sister leaves under equal conditions of temperature, etc., produce equal masses of roots in equal time.

Experiments were made also on polar regeneration. When the lower stem of a plant is placed in water, roots develop on the lower portion of the stem and leaves on the upper portion. This is called polar regeneration. Loeb says there are two possible explanations of the phenomenon: First, the different chemical composition of the ascending and descending sap—the sap rising in the stem contains in solution the elements that have been taken from the soil; the descending sap contains the sugars that have been synthesized from the carbon dioxide and water of the air; second, the different cell patterns (the anlagen) at the two poles of the plant. The author concludes that his experiments rule out the first possibility. Regeneration of roots in one part and shoots in another is due to primary differences in the anlagen of the cells.

So much for the experimental data. Let us now examine Loeb's philosophical deduction that "the process of regeneration was thus revealed as a purely physico-chemical phenomenon." Loeb has fallen into the grievous logical error of confusing *causation* with *prerequisite conditions of causation*. One is not surprised to find that equal masses of sister leaves under the same conditions produce equal amounts of shoots or leaves or that the flow of sap to certain cells, made more abundant by the mutilation of the leaf, and directed by the force of gravity, should stimulate particular cells to activity. But can one logically infer from this that the cellular process of assimilating the sap and converting it into shoots and roots characteristic of the species, was *caused* by the physical forces which brought the sap to the cells and the chemical forces resident in the cells and the sap? The author has hit far from his mark. The processes, it is true, were *occasioned* by the physico-chemical phenomena, but before one can conclude they were *caused* by them he has a long way to go. He has to show first that these forces can produce from lifeless chemicals the wonderful structure of the living cell and organisms with their combined unity and complexity; and secondly that they actually do accomplish these results. We have seen many interesting chemical reactions in the test tube but none that would justify us, without doing violence to reason, in assuming that of themselves they *cause* a living cell. We might as well say that meat and bread and air and water *caused* Raphael's Madonna. These were undoubtedly antecedents and essential prerequisites for the processes that wrought the painting, but who would maintain that they were the cause of the processes?

Mechanism may be adequate enough for the working purposes of the scientific investigator in his laboratory, but as a philosophical system it falls to the ground. Does Vitalism offer a more satisfactory solution of the phenom-

ena of life? Is Loeb justified in saying that the Vitalists' explanation of these phenomena is "either purely verbalistic, such as the assumption of a guiding spirit in each organism which directs growth according to a preconceived notion (the entelechy of Driesch) or, they were based on assumptions plainly in contradiction with facts." (p. 6.)

Unfortunately, the Vitalists, it seems to the writer, have frequently injured the cause of Vitalism, first by the type of arguments they have employed, and secondly by the obscurity in which they have clothed the concept of vital principle. Processes in the organism that can not be explained by the existing knowledge of chemistry and physics are triumphantly pointed to as postulating a vital principle. Before the synthesis of urea in the laboratory by Woehler in 1828, it was the organism's production of "organic" compounds; in recent times it has become delicately adapted mechanisms, such as respiration. Later when these facts are explained through advances in physical and chemical sciences faith in vitalism is weakened.

Let us turn to Driesch, one of the most able exponents of Vitalism. Having devoted a number of pages to the inadequacy of the physical and chemical theories of morphogenesis, he makes the statement upon which he bases some of his arguments for the vital principle, that "atoms or molecules by themselves can only account for the form which is arranged, so to speak, according to spatial geometry—as in fact they do in crystallography; but they can never account for form such as the skeleton of the nose, or hand or foot." [8]

This statement can not be accepted unqualified. Not many years ago there was born a new science that is now known as colloid chemistry. Still in its infancy it promises to shed much light on the world of science. Applying the

[8] Driesch, H., *The Science and Philosophy of the Organism*, London, 1907, Vol. 1, p. 137.

principles of colloid chemistry, Stephen Leduc[9] has shown how solutions may be prepared in which inorganic salts agglomerate (the growth of plants) into structures resembling seaweed, mushrooms, toadstools, etc., and in some respects the internal structure resembles the structure of cells in living organisms. Although there are a number of dissimilarities—no cell division, no metabolism, etc., nevertheless, these artificial organisms demonstrate that physical and chemical forces can produce arrangements of molecules otherwise than according to the principles of spatial geometry. Dr. Martin H. Fischer[10] has likewise shown that growth curvatures, "spirals and other irregularities in growth, such as characterize flowers," can be mimicked in the laboratory with thin strips of gelatin painted at different spots with a little acid and dipped into water. Is it not therefore within the realm of possibilities that the form of the internal and external structures of plant and animal organisms may be determined by similar forces? Does not the possibility seem less remote when we consider the complex chemical nature of living organisms? These facts do not argue against Vitalism but they do weaken the arguments of the Vitalists.

Teleology is another favorite argument of the Vitalists. They point to the fact that teleology or purposefulness is everywhere evident in Nature. By this they mean that the structure of both plant and animal organisms and their manifold organs are admirably adapted to peculiar types of function which serve to maintain the integrity of the organism or insure its continuance through propagation. It can not be logically held, they contend, that the physical and chemical forces of Nature, could of themselves be so ordered for purposeful ends; there must be a vital principle—the entelechy of Driesch—in each organism to con-

[9] Bechold, H., *Colloids in Biology and Medicine*, tr. by Bullowa, N. Y., 1919, p. 254.

[10] Fischer, Martin H., *Oedema and Nephritis*, N. Y., 1921, ps. 446-451.

trol and direct these forces. The argument is sometimes put in the following form: Suppose one should see a heap of brick and stone and sand and mortar, and then later return to find these assembled in the form of a beautiful house. Would one say that the forces of Nature—gravity, atmospheric pressure, chemical attractions — built the house? Would he not be forced to acknowledge that some guiding principle was responsible for the structure? In like manner, are we not forced to recognize a guiding principle in living organisms that have been constructed from the raw materials of air, water, organic and inorganic chemicals? A machine, says Driesch, can not afford us the means of understanding what happens in the organism; there is a "natural factor at work, *autonomic* and *not* resulting from a combination of agents, but elemental in itself." [11]

At first sight this argument appears to be convincing, but in the opinion of the writer it is not suited to bear up under criticism. For, although one must admit that the teleological structures and mechanisms of the organism can not be explained by the blind forces of Nature, is there no other alternative than an immanent vital principle governing them? Could not an extrinsic Infinite Intelligence direct these forces to the accomplishment of particular ends? Furthermore, does not the teleological adaptation of organs and mechanisms imply that the vital force exercises some kind of intelligent control? How can an end be perceived and the means applied to the realization of that end except by an intelligent agent? The Vitalists would not be willing to ascribe intelligence to the vital principle in plants and the lower animal organisms; even in the human organism adaptation obtains in the earliest embryonic stages, long before there is any exercise of the faculties of intelligence. The only alternative left is that the

[11] Driesch, H., *Op. cit.*, Vol. II, 1908, p. 136.

vital principle operates blindly to affect wonderful adaptations. Ultimately we are driven to the admission that this faculty of the vital principle has been determined by the Infinite Power that established its nature. Is it philosophically more unreasonable to hold that a Supreme Intelligence adapts the forces of Nature for living organisms by an extrinsic control, than to say that He acts mediately through a blind directive power of a vital principle? The argument of teleology therefore proves nothing more than a directive control exercised over living phenomena by a Supreme Intelligence.

When we come to inquire into the nature of the vital principle, we find that on this point the Vitalists are extremely obscure. Probably on this account, more than for any other reason, Vitalism has fallen into disrepute among men of science. Is the vital principle, as Verworn calls it, some mystical unknown power, or, in the words of Tigerstedt, "a capriciously changing spectre"? Driesch is not very illuminating on this point. "Entelechies," he says, "are *not* energies, *not* forces, *not* intensities, *not* constants, but—entelechies. Entelechy, as we know, is a factor in Nature which acts teleologically. . . . It acts by suspending and setting free reactions based upon potential differences regulatively." [12]

The objection immediately suggests itself: how can an entelechy suspend or set free a reaction unless it itself is a force or an energy? Can anything but a force of some kind overcome the inerta of either a static or a moving system? "Entelechy," says Driesch, "is order of relation and absolutely nothing else." This statement is but a bare description of phenomena; it is not even an attempt at an explanation. Haldane[13] is as obscure as Driesch.

[12] Driesch, H., *Op. cit.*, Vol. II, p. 169 and 205.

[13] Haldane, J. S., *Mechanism, Life and Personality*, N. Y., 1923; also, *The Organism and Environment as Illustrated by the Physiology of Breathing*, N. Y., 1917.

The scientist of today, therefore, finds himself between the Scylla of Mechanism on the one hand and the Charybdis of Vitalism on the other. "As a physiologist," writes Haldane, "I can see no use for the hypothesis that life as a whole is a mechanical process. This theory does not help me in my work; and indeed I think it now hinders very seriously the progress of physiology. I should as soon go back to the mythology of our Saxon forefathers as to the mechanistic philosophy." In the field of biology we are confronted by countless phenomena that can not be given an ultimate explanation by a mechanistic philosophy—ontogenetic development, heredity, reproduction, regeneration, instinctive and affective reactions, and a thousand others. Sherrington, one of the eminent physiologists of the present day has stressed the inadequacy of mechanistic thought.[14] Yet when the scientist turns to Vitalism he meets there the spectre of the vital principle that is not a force, not energy, but only entelechy.

Wherein then lies the solution to this perplexing problem? It is obvious that it rests on a philosophical doctrine of the constitution of matter. Let us then begin with the data of science, for sound philosophy must be based on the facts of science. For a long time it has been recognized that matter is made up of infinitesimal particles that are constantly in motion. Until recent years it was generally held that these particles could be reduced to a number of elements, differing from one another in their inner constitution. Through the work of Rutherford and Soddy science entered upon a new era when in 1903 these two men put forward the theory that "the radiations from active matter accompanied a veritable transformation of the atoms themselves." [15] This view was confirmed by the observations of Sir Norman Lockyer that the spectral lines

[14] Sherrington, C. S., *Some Aspects of Animal Mechanism. Mental Hygiene*, Jan., 1923.

of the hottest stars are predominately helium and hydrogen. As the stars cool the spectra become more complicated and heavier elements appear, a fact which indicates that the so-called elements are not elemental after all, but formed from hydrogen or helium or both. These discoveries together with the researches of Mme. Curie on radium and radio-activity would seem to justify the view that all matter may be ultimately reduced to one substratum. According to this scheme, the common substance that we have called the substratum is divided into infinitesimal particles that bear an electric charge (the electrons). Carbon differs from silver in its chemical and physical properties because its molecules are made up of a different number of electrons with different spatial relationship of their electrons than the molecules of silver. In this manner the elements differ from one another.

Modern discoveries in science, therefore, are leading us back to the old scholastic doctrine of matter and form. The Scholastics taught that all things of the universe are constituted of the same substratum, primal matter. They are differentiated from one another by a substantial form, an *actus primus,* which is not just entelechy but a definite entity, a specific internal energy that determines the disposition of primal matter. Living things are essentially different from non-living because there is an essential difference between the internal energies of the two.

Insufficient data, however, at the present day, leave the electronic theory of the constitution of matter that we have outlined in the category of scientific assumptions. Let us not then anticipate the future of science, especially since our problem has to do not with the common underlying substratum, but only with the differentiation between animate and inanimate nature. The known and tested facts of science are sufficient for our purpose. We have referred

[15] Rutherford, E., *Annual Report of the Smithsonian Institute,* 1915, 167-202.

to the work of Rutherford and others merely because its philosophical deductions, as will be seen, harmonize with our conclusions drawn from other facts of science.

Carbon and oxygen are two distinct gases which combine under certain conditions to form a stable gas, which is different from either the carbon or the oxygen. Place a solution of calcium hydroxide (ordinary lime in water) in a beaker, pass through it some carbon dioxide and the liquid will become cloudy, a precipitate is formed. The calcium hydroxide and the carbon dioxide have reacted to form calcium carbonate, a substance insoluble in water. In the first place we had the molecules of carbon and the molecules of oxygen; then the molecules of carbon dioxide and the molecules of calcium hydroxide, and finally the molecules of calcium carbonate and water. In each case (apart from the reactions) the elements or the compounds were being constantly acted upon by external forces—bombarded by the particles of the gases in the air, the molecules of water, etc., yet they maintained their identity. How was this accomplished? It is evident that there was some kind of inner energy holding the atoms (or the electrons) together in a stable system. This inner energy corresponds to the Scholastic concept of *forma substantialis*. When elements unite to form a compound, or when compounds interact to produce new compounds, there results a different dynamic arrangement, a different type of inner energy—the *forma substantialis* is changed.[16]

Now let us take a living cell, the ordinary amoeba. It is acted upon by the physical and chemical forces of the

[16] For an exposition of the scholastic doctrine of matter and form the reader is referred to the following: Hickey, J. S., *Summula Philosophiae Scholasticae*, Vol. II, 144-174, Dublin, 1914; *Sti. Th. Aquinatis, Opera Omnia*, Rome, 1886. The following references: *Quodlibita IX*, Art. 6 ad 3; *De principiis Nat. and Opusculum* XXX; *De Coelo et Mundo*, Lect. 6 in 1 am; *Commentarium in Octo Libros Physicorum Aristotelis*, Lect. 13; *De Generatione et Corruptione*, Lect. 5 etc.; *Summa Pars Prima Qu*, 76, Art. 4 and Qu 75; *Contra Gentiles*, Bk. 6, Qu. 115, Art. 1 ad 2 am.

medium in which it is bathed, yet it maintains the identity of its own protoplasm. How is disintegration prevented in the presence of these various forces? It is evident that there must be some kind of intrinsic energy, preserving the specific spatial arrangement of the atoms or electrons. This intrinsic energy, call it what we will, corresponds to the scholastic *forma substantialis.*

From this it follows that both animate and inanimate nature have in common a *forma substantialis.* Wherein do they differ? It is a philosophical axiom that the nature of an action follows the nature of the agent. Between living and non-living things there is a fundamental difference. In the former, a mutual interaction with external substances changes their nature. If iron, for example, combines with oxygen, it rusts and is no longer iron but iron oxide; if a molecule of carbon dioxide, a harmless gas, loses an atom of oxygen, it becomes carbon monoxide, an extremely poisonous gas. With living things, however, the case is different. They not only have the capacity of a mutual exchange with external media without losing the identity of their specific cells or organisms, but on the other hand, this exchange is even necessary for the maintenance of the existence of the living organism as such. The only apparent exceptions of which I am aware are the nerve cells and the seeds of plants. As to the former, evidence has been brought forward[17] (contrary to the old belief) that functioning nerve cells give off carbon dioxide, consequently assimilate carbon and oxygen. As regards seeds these have potentially the capacity of a mutual exchange with external substances, and, as a matter of fact, do not function as living things, unless this potentiality is activated.

[17] Tashiro, Shiro. *A Chemical Sign of Life.* Chicago Univ. Press, 1917. Parker, G. H., *Journ. Gen. Phys.*, VII, 5, May, 1925, 641-669. *Idem.*, VII, 6, July, 1925, 671-677.

The difference then between living and non-living matter, according to this concept, is not a generic but a specific one. The differentiating *forma substantialis* in each instance is an immanent energy. According to this concept a non-living substance may be regarded as a non-adaptive, a living thing as an *adaptive* dynamic unity, the word *adaptive* being used in the sense of a continuous adaptation of inner and outer relations.

Does the scientist object that the notion of *forma substantialis* is not sufficiently clear, because we have not defined the nature of the immanent energy? If he does, we might bid him hold his peace until he gives us some satisfactory information about the intrinsic nature of physical energy. We see it in its various manifestations, heat, light, electricity—but where do we find a satisfactory definition of its nature?

We do not mean to infer, however, that we are satisfied in merely demonstrating the necessity of the postulate of a *forma substantialis*. The depths must be explored; its nature determined. But here we are getting into the field of ontology and this is not our purpose. Nevertheless it may be noted at this point that the facts of science indicate the *forma substantialis* to be not a property, not an accident, but a substantial entity. The internal energy that holds atoms and molecules in a particular spatial arrangement can not be a property of extrinsic forces. If it were, the atoms and molecules would be continually changing with variations in the atmospheric pressure, etc. The *forma substantialis* therefore is an energy in itself—a substantial entity.

The *forma substantialis* of living and that of non-living things have been shown to be intrinsically different. Is there likewise an essential difference between the *forma substantialis* of single and multiple cell organisms, and between man and the remainder of the animal kingdom?

These questions suggest an interesting problem that will be discussed in a later paper.

Vitalism, when grounded on such a basis as the scholastic doctrine of *materia prima* and *forma substantialis* offers no stumbling block to the scientist. Such a doctrine does not propose a mystical elusive entelechy but postulates an immanent energy as real as the energy that sets aglow the wire in an electric bulb. This immanent energy is the stern demand of science itself. Let the physiologist engage in his researches and discover all that can be learned about the functions of plant and animal organisms. Experimental data are not feared by the philosopher. On the other hand they serve him in the quest of ultimate causes. *Actio sequitur naturam.* The actions or the functionings of the organism as discovered by the man of science should be a searchlight to the philosopher in studying the nature of the *forma substantialis.*

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AN ELECTROMAGNETIC THEORY OF MATTER, LIFE, AND MIND

THE aim of the philosophy of science is to rationalize the facts of nature; that is, to introduce order into the chaos of facts yielded by the various sciences by exhibiting the interdependencies of these facts as part of that system of things which has been called the "order of nature." To accomplish this synthesis it must be possible to show how the individual phenomena within any restricted field can be fitted into a wider scheme as logically consistent items within a universal framework. This implies that the processes involved in the various isolated phenomena of nature are, at bottom, similar in character. As Poincare[1] states the matter, every generalization supposes a belief in the unity and simplicity of nature, and, we may therefore add, progress in science can only be achieved by the formulation of theories of increasingly wider scope. In consonance with this postulate that there is as Ariadne's thread running through the tapestry of evolution I shall try to indicate how a set of generalized formulae might be arrived at holding for the integration of material aggregates, as well as for protoplasmic synthesis and the unity of "mind." The hypothesis herein set forth may be designated as a "universal behaviorism" or a "monism of action."

[1] *Science and Hypothesis*, London, 1905, p. 145.

Induction and the Uniformity of Nature

To begin with, any theory of nature which hopes to explain the abundant success of the empirical sciences in the prediction and control of the events of nature must provide a theory of induction which will effectively answer the scepticism based upon Hume's destructive criticism of induction.

It is an axiom of science that under similar conditions the same things behave in a similar fashion. This is an empirically verified fact, on the same level with the observation that two bodies (or points) can not occupy the same space at the same time, or that the same body can not be in two different places at the same time. These axioms seem to define the "natural" order of events. Any sequence of events which disobeys these principles would, like the spooks of the spiritists, be properly regarded as "supernatural." Why this should be the natural order, rather than some other arrangement of happenings, remains to be explained. Indeed, some of the phenomena underlying Max Planck's quantum theory of energy and Niels Bohr's theory of atomic structure seem to intimate that this "natural" order may even be defied, to a certain extent. Results seem to indicate that electrons may jump instantaneously from one orbit to another in the atomic solar system. Now this appears suspiciously like being in two places at the same time. With characteristic disrespect for our conventional notions, Bertrand Russell, in his *A, B, C of Atoms,* has suggested that perhaps the electron does not traverse the intervening "space" between the two orbits. Personally, I should be inclined to ask how one can be certain that it is the "same" electron in the inner orbit that made the leap from the outer one, and *vise versa.* Perhaps the elec-

tron "dies" in its original orbit by untwisting itself in another dimension, with the conserved energy being "reborn" in the new orbit by tying itself up in a new knot or impenetrability in space-time. However, the situation may not be so hopeless as to put us to permanent intellectual confusion, and what seems to be the misconduct of mischievous electrons may appear more rational when we have readjusted our conception of what the ethics of cosmic conduct ought to be. That is, we may discover one of those new simplicities which Poincare believed to underly the possibility of science.

The various attempts which have been made to provide a theory of induction usually rests upon the belief that the orderliness of nature is due to a conservative tendency in the cosmos. The "law of parsimony" and the "principle of continuity" are expressions of this faith in the ultimate rationality of things. The principle of the conservation of energy is usually appealed to as the physical background of the uniformity of nature, but since this principle, sometimes called the first law of thermodynamics, is now, like its partner, the second law of thermodynamics, interpreted as being a statistical generalization, there is some question as to the validity of grounding the uniformity of nature upon it. Moreover, it is the quantity designated as *action,* or energy integrated through time, rather than energy itself, which is conserved. Perhaps this is because "action" represents the "curvature" of the *world,* or the space-time manifold. Some exponents of the theory of relativity have stated that the "principle of least action" is the only classical generalization which remains intact in the new physics—though, again, A. S. Eddington believes that its integrity is threatened by the application of the postulate of the quantum theory that action is discontinuous in character.

So far as the present writer is informed, the best theoretical justification for the faith in the uniformity of nature is set forth by Dr. S. Alexander,[2] who grounds order in the uniformity of curvature of that most pervasive framework and matrix of nature, Space-Time. The logical theory presupposed in the present essay is that the *concept* or definition of a "thing" is a matter of giving its law of behavior. *A thing is what it does.* Thus, energy, living matter, and mind, are not mysterious and ineffable entities; they are simply what they do—their modes of behavior. But *concepts,* some philosophers will object, are mental products, arrived at through a process of abstraction and generalization. It is here that I find Dr. Alexander's doctrine is of peculiar value in providing the theoretical basis for induction, for it is the only theory of concepts and categories which spans the gap between mental habits and the external universe—thus answering Hume's scepticism. Adapting his view to our particular needs, we may answer this question largely in his own words. In a universe of Space-Time, universals or concepts are spatio-temporal habits or patterns of motion. Universals are the generative plans of action which can repeat themselves in particulars because Space-Time is uniform, *i. e.,* has a constant curvature, and therefore behaves on plans which are undisturbed by differences of place or time. Thus, as Alexander says, the universal is related to its particulars as the equation of a curve is related to the instances of it which may be obtained by varying the so-called constants in the equation. In this fashion conceptual processes of induction appear as special cases of the orderliness of the cosmic continuum.

To a certain extent Alexander's theory runs counter to the theory of relativity. He, like A. N. Whitehead, conceives the uniformity of curvature of the metrical manifold

[2] *Space, Time and Deity,* Vol. I, p. 263, and Vol. I, Bk. II, Ch. III.

to be due to the universally isotropic character of Space-Time.[3] Thus matter appears to be a mutation within an historically prior stuff, Space-Time (an "ingredient" in events which "does not pass," in Dr. Whitehead's terminology), whereas for the "orthodox" school of relativity space and time could not exist if there were no matter. There are certain advantages and difficulties adhering to both views. On the whole, it seems to me that it is more difficult to suppose that "matter" could "emerge" from space-time than to suppose that the space and time continua are abstractions from a universe of space-time-matter. However, we may retain the advantages of the Alexander-Whitehead view by assuming that, aside from the local unevenesses of the field, which constitute what we call matter, space as a whole has a constant curvature which is determined by the average density of matter, or its "mean" distribution in space-time. What we need is not a new theory of space and time, but a new theory of "things" in the space-time continuum.

Thermodynamics, Evolution, and the Irreversibility of Time

The paradoxes which seem to arise in dealing with the problem of the notion of time in relation to quantum mechanics and thermodynamic probability are discussed by Professor Wm. S. Franklin[4] and Dr. A. J. Lotka.[5] These paradoxes take their origin in the fact that in dealing with the relations obtaining between atomic structure and the radiant energy which is absorbed or emitted by revolving

[3] G. Temple, "A Generalization of Professor Whitehead's Theory of Relativity," Proceedings of *The Physical Society of London*, Vol. 36, pp. 176-193.

[4] "The Quantum Puzzle and Time," *Science*, Vol. LX, 258-261.

[5] "Probability-Increase in Shuffling and the Asymmetry of Time," *Science*, Vol. LIX, 532-536. See also "Two Models in Statistical Mechanics," *The American Mathematical Monthly*, Vol. 31, 121-126.

electrons in atomic orbits discontinuity of time and space seem to be implied. Indeed, this discontinuity is embodied in Planck's quantum theory of energy and Bohr's postulate concerning the discrete series of states allowed in atomic action. Various phenomena of this order suggest that the ordinary laws of classical mechanics (what Professor Franklin terms "macro-physics"), even as modified by the electrical theory of matter, are not applicable to the phenomena of "micro-physics."

Both authors seem to assume that the ordinary processes of nature, especially those of an evolutionary order, can be identified with the progress of an irreversible time order, which is related to the thermodynamic probability of these systems, *i. e.*, the increase of *entropy* which follows in accordance with the second law of thermodynamics. The thing which seems to baffle these investigators is that man, whom we all regard as a product of evolutionary processes should have developed an intuitive consciousness of time which is of an irreversible character. This unidirectional order (*e. g.*, recognition of *before* and *after*), as Lotka points out, is exhibited in our process of chord resolution in melodic progression. Consequently, when we come to the infra-atomic realms previously mentioned, where our ordinary intuitions of space and time break down, we discover that we are in the serious predicament of trying to explain facts which are essentially inexplicable. That is to say, we are confronted with a set of empirical facts which contain what seem to us to be irrational elements, for we find that our customary principles of causal relationships no longer hold. Logically viewed, the ultimate laws of thought, and the spatio-temporal nexus of things, are reducible to transitive and asymmetrical relations, and our ordinary habits of thinking have become so ossified that we can not conceive that nature can act in any other way than in accordance with these principles.

By way of an approach to a solution to this problem I wish to express my surprise at the tacit assumption that discontinuity of action is restricted to micro-physics, and is a thing unique in nature. Contrary to the assumption that nature makes no jumps, it seems to me that this is what she is doing "continuously." Nature is a "hopping fool." In a word, discontinuity is as real a feature of natural processes as continuity—perhaps more real.[6] It seems to me that mutations in biology are quite comparable to the granular nature of energy in physics, and that the latter is no more and no less mysterious than the origin of chromosomes. The mechanical aspect expresses the irrelevancy of time, and the standardization of processes so that they are continuous with the "past." Variability, which, in one sense, is inexplicable in that it can not be deduced from antecedent conditions, expresses the progressing series of events which is discontinuous with the past.

This, however, does not compell us to regard space and time as discontinuous. It is the things in the space-time medium which are corpuscular. Space and time are abstractions from the universe of space-time-matter. This, of course, carries with it the idea that probability is also discontinuous. If we interpret the second law of thermodynamics as the expression of the tendency of orderly motion to become mixed up, we face the problem of explaining how, if a disorderly tendency exists in nature, it is that this chaotic tendency is sufficiently suspended so as to allow nature to arrive at higher unitary modes of behavior of atomic and molecular syntheses. The theory which I wish to propose is that these discontinuities of the strata of nat-

[6] To a certain extent continuity is illusory. Even what is taken to be continuous movement is sometimes corpuscular—Bergson to the contrary, notwithstanding. When I make a movement, such as a sweep of the arm through the air, the gross muscle contraction really consists of a finite number of jerks, *i. e.*, "all or none" pulses, both in the nerve and muscle cells. The unfied character is due to an "averaging" effect. Each of these jerks can be decomposed into sub-jerks—at least conceptually.

ure, with their new laws of behavior, emerge when the microscopic whirls of events are unified into the groups of behavior which may be termed *macroscopic rhythms.*

What Is a Thing?

The fundamental fact of nature is a space-time fact. Pure substance and pure movement are ideal limiting notions derived from this static-dynamic reality. I shall use the term *behavior-stuff* to define the analytic-synthetic "boundary conditions" of the elements of the "aether of events." Substance, or the relatively permanent structure of any "thing," is that synthesis of movements which remains *invariant* during the time interval in which it is observed. But the thing is not one and the same through all time.

Whenever we have a group of micro-movements unified into a macro-movement we have a new "quality" emerging. Quality is the "mind" (or the Aristotelian *form*) of a structural edifice in the sense that it is the functional unity—or a dynamic synthesis—of the components of a behavior complex. *Red,* for example, as a quality, may be considered as consisting of a great number of individual events (external wave frequencies, and moving electrons in the nervous system), unified into what L. T. Troland calls a "group frequency." This "condensation" is not brought about, as Bergson holds, by the vital impetus or *durée,* but is a matter of physiological summation. (At least, the total "brightness" of complex light is the retinal summation of the individual brightnesses of the separate wave-lengths of the monochromatic constituents.)

Whether in the "percipient event" the observing organism superimposes this unity upon the group of multiple elements with which it is "cogredient," or whether this unitary mode of behavior is a real feature of the extra-organic

thing itself, is an old and an ever-new problem. Eventually the difficult notion of "simultaneity" is involved. I have stated all that I have to say on this subject in another article.

Every entity, excluding electrons,[7] whether an atom, molecule, chromomere, or cell, is an entity in the sense that it summarizes a group of random movements into a new unitary mode of behavior, which retains an integral value with respect to the field or environment in which it is imbedded. Every unitary group of movements expresses the "central tendency" of a statistical configuration of micro-events, which vary within narrow limits around a mean position. Any *thing* is a kind of statistical constant of high stability (*vide* "isotopes"), but in the transition states from one behavior complex to another the *probability becomes discontinuous,* and *a priori* induction gives way to the empirical observations which record the "history" or forward movement towards the "cone of the future," which is the asymmetric time order of evolution.

Matter and the Field

In developing the theory of a monism of action the as yet unresolved, and perhaps ultimate, dualism of physics,

[7] The electron is deliberately excluded for the reason that if, as A. S. Eddington supposes, the circumference of the universe, the greatest length in nature, determines the size of the electron, the smallest thing in nature, then matter is not infinitely divisible. The indivisibility of the electron is perhaps the expression of the absolute impenetrability of the space-time which the electron occupies. This may be due to the character of the unevenness in the electromagnetic field in which the electron is immersed. If the universe were Euclidian in structure, matter might be indefinitely divisible—electrons being made up of proto-electrons, and so on—but if, as Einstein supposes, the macro-universe is a finite, though unbounded, curvilinear space-time continuum, the radius of which Silberstein, basing his calculations on the conception of De Sitter, estimates at over one hundred million light years, then matter, if its minimal dimensions are determined by this curvature, must of necessity be of finite divisibility. Conceptually matter may be indefinitely divisible, but physically the divisibility of matter depends upon the law of "convergence" of the series.

the dualism of *matter* and the *field,* has supplied the pivotal concept. I wish to portray this dualism as the bottom-most homologue of the pervasive relationship, which appears on all levels of nature, between the static and dynamic, the structural and the functional aspects. In other words, the dualism of *matter* and *energy,* of *protoplasm* and *life,* of *body* and *mind,* are only special cases of the same relation obtaining between electrons and their electromagnetic fields of force. The material organization of the universe expresses the static,—what has already been accomplished, and functioning in accordance with which constitutes the mechanical aspect of nature. But in addition to standardization, there is variability—the movement towards the cone of the future, or the tendency towards higher behavior-complexes as unitary modes of behavior. This tendency towards variability introduces novelty and unpredictability into nature; it is in this discontinuity with the past that new laws of behavior take their origin. But first let us see how this view is to be squared with the theory of relativity. (We are not here concerned with the "special" principle, but with the general theory of relativity.)

Popularizers of the theory of relativity have familiarized us with the relativistic view of the world as a four-dimensional space-time continuum, the geometry of which describes the history of material particles in space as observed visually. Here, in the theory of relativity, we have the uniform formulation of all the phenomena of physics which Riemann visioned. Into this four-dimensional manifold, or "tensorial construct," we human beings have introduced the element of change by our resolution of the components of the world into the rectangular coordinates of cartesian geometry, and the independent axis of time. It is this arbitrary time dimension which stratifies the universe into the static and the dynamic.

However, the world can not be a pure continuum. Somehow, we must derive the property of discreteness, for which what we call "matter" is only a name. To say that motion itself may be corpuscular does not help us. Now according to Minkowski the universe is a system of *world-points*, the courses of which generate *world-lines*. Extending this idea, we might view the history of the world as the progressive tangling up of world-lines, not, however, as abstractions or limiting lines of the pure space-time continuum (as points and instants are ideal limiting notions), but as actual realities. Herein lies the domain of physics as contrasted with the field of pure mathematics.

The elements of the real world must possess a fibrous structure, if our picture of history as a process of tangling up world-lines is of any value. Let us posit that space, instead of being empty, is really filled with lines of force, and that these lines are so ordered that even though they cross and irradiate in such a fashion that the whole of space is spiderwebbed with them, nevertheless, they are concentrated with maximum density at certain nodal points, so as to cut out electrons by their opposing curves of action in perhaps something of the same way in which the interference of light waves generates zones of brightness and darkness. Space, then, in reality is the field of energy. Since energy is stored in the space we call the field, energy may be defined as the impulse directed towards changing spatial position. But since all matter is on the move (*rest* being a zero case of motion with respect to some chosen frame of reference), and since there is a reciprocal relation between matter and the field of energy in which it is suspended—so that we may say that space-time contains as much matter as it can hold, and that if one electron comes into existence in one space-time contour another must go out of existence to make "room" for it—since all this is foundational to reality as conceived in a universal

behaviorism, matter can consequently move only in the direction of building up higher unitary modes of behavior in the cosmic field. Physical integration expresses this pressure of the field of force upon matter, and material objects are moving compromises generated by opposing curves of action.

The manner in which this view differs from naive materialism is briefly stated. Electrons are not hard, round elements, which are self-sufficient, snobbish, and aloof from their environments. Electrons, like organisms, must demonstrate their fitness to survive in the struggle for existence, so they must therefore be on friendly terms with their neighboring fields of energy—else they will be snuffed out of existence!

The moving electrified points we call electrons are parts of, or knots in, continuous threads. The process of physical integration is one whereby these strings become twisted up into ropes, as one investigator has proposed. Objects differ as they tangle or untangle more or less filaments or strings of energy. Evolution is a process of tying energy-knots in the field. The more free energy of space-time is bound up the more complex the "thing" becomes. On the whole the process of assimilation must be compensating to the process of dissimilation, and so if the universe is "running down" in one corner of space-time it must be "running up" somewhere else. These standardized patterns of bound energy—or "boundary-singularities of the field," as H. Weyl calls them—are the impenetrabilities of space which arise in the electromagnetic field.

Electrons and Radiant Energy

What I wish to emphasize is that there is a very intimate relation between matter and the radiant energy stored

in the circumambient space-time of material nuclei. How this interchange takes place is still a mystery, but that it does take place is a fact. It is essential to the understanding of the theory herein urged that it be accepted that chemical action would be impossible if it were not for the radiant energy interfused throughout space, and in which atoms and molecules are imbedded. These wave trains of energy extend above and below the series of frequencies which, through some electro-chemical reaction, affect the light sensitive elements of the retina. Luminous energy is only one kind of radiant energy, and since the relation between matter and its field of energy is always specific, the kind of frequency which is tuned to one stage of material synthesis is not synchronous to another status of matter. For instance, the light waves active in photo-synthesis by chlorophyl are not of the same frequency of radiant energy as those which have built up nervous tissue, and so on. Why iron, and to a lesser extent other metals, should be responsive to magnetic force is still a mystery. *Ultimately mathematical ratios and the principles of space-lattice groupings determine the relations of responsiveness between wave frequences and the configurations of matter which are sensitized to them.* Here music and mathematics meet, for the rhythmic pulsations of energy which build up loci of material resonators are resolved by harmonic analyzers into the numerical values of the components of the corresponding Fourier's series. Even the "densities" of physiological rhythms may be interpreted as the "modulations" which the melodic progression of the cosmic tempo has impressed upon the "waves" of evolutionary advance.

For theoretical physics the difficulty lies in trying to reconcile the granular nature of energy with the phenomena of light wave interference. Some data suggest that light must be of a corpuscular nature, as Newton supposed, while other phenomena seem to necessitate that it be a wave

motion in a continuous medium. But the relation between this something which undulates (the aether), and matter has defied all experimental attack. On the other hand, if light be corpuscular, being but a train of "light-darts," why should these bullets or quanta of energy trace out wave-like trajectories? This is the mystery which has baffled all ingenuity. As Sir William Bragg has said, we use the aether theory half the time and the corpuscular theory the other days of the week. As with other human beings, we can't get along very well with the aether and we can't get along without it. The aether has the same unsocial sociableness which Kant found in man. For the present, like Professor W. P. Montague, I shall simply assume that the newer view of the conception of the field of energy has supplanted the older conception of the aether.

A wave of radiant energy must consequently be regarded as a periodic disturbance in the electromagnetic field of energy progressing through the space-time manifold. This progressive disturbance possesses some of the properties of matter, such as *inertia,* but it can not possess all the properties of matter, for it would then *be* matter. The only suggestion with which I am acquainted, which may possibly provide an explanation of this interchange between matter and radiant energy, has been put forth by Sir Oliver Lodge.[8] As Lodge points out, the pressure of light as conveying energy, is a longitudinal phenomenon, whereas an electron is a rotational phenomenon. In trying to understand the relation between light and electrons Lodge avers that *an interchange of energy between a linear vibration (oscillator) in one direction and a rotational vibration (oscillator) in a plane at right angles to it can occur when the two modes are synchronous or properly attuned,* and that illustrative models for this were constructed by Professor Wilberforce in 1894. I mention this because the

[8] "The Aether and Electrons," *Nature,* Vol. 113, 185-192.

solution to this problem is necessary to the view herein presented. This, however, is the physicist's problem.

Quantum Tubes of Force

It was stated that the ultimate dualism of nature is that of matter and the field. But speculations in this realm hold out the hope that this is not an unbridgeable hiatus. The manner in which the conception of advancing trains of radiant energy may be assimilated to the notion of discrete matter was first pointed out by Faraday[9] in his theory of electric and magnetic tubes of force. This view of radiation as a species of vibration in which the lines of force which are known to connect particles and masses together has been extended by E. T. Whittaker[10] and H. S. Allen,[11] who regard discrete quantum tubes of magnetic force as physical realities. J. J. Thompson has also lent this view his approval, suggesting that an electron is simply the end of a Faraday tube of force.

Electromagnetic and luminous radiations are of the same kind, the only difference being in the length of waves. Now Professor Whittaker's four-dimensional electromagnetic tubes of force include as special cases both kinds of Faraday tubes. In discussing the properties of these discrete tubes Whittaker has made it clear that such tubes would satisfy all the demands of the theory of relativity, and would involve the electric and the magnetic vectors, at right angles to each other, and, at the same time, providing a geometrical integration of the Maxwell-Lorentz equations of the electromagnetic field. These tubes of force may

[9] "Thoughts on Ray Vibration," *Philosophical Magazine*, May, 1846.

[10] "On Tubes of Electromagnetic Force," *Proc. Roy. Soc. Edin.*, Vol. xlii, 1921, pp. 1-23.

[11] "Aether and the Quantum Theory," *Proc. Roy. Soc. Edin.*, Vol. xli, pp. 34-43.

enable the physicist to reconcile the apparently discontinuous nature of the wave-front (having a "speckled" structure, as J. J .Thompson says), with the reciprocal conversion of matter and radiation which Lodge, along with others (including R. A. Millikan, Sir William Bragg, and J. H. Jeans), has hypothecated. These views are superlatively interesting and important in that they may eventually lead to that final synthesis towards which our minds are constantly driven.

The Generalized Problem of Integration

To account for the most characteristic feature of evolution we must be able to understand why it is that matter aggregates into more complex units, which, for a time, maintain a relative permanence, but which nevertheless are dynamic equilibria so unstable as to be continually breaking down under the stresses of internal and external agencies, in some cases the aggregates being sucked under in the onward sweep of nature, and in other cases, where the lines of advance are sustained, integrating into more complex aggregates leading to still higher dynamic syntheses.

At the lowest physical level instability, the inherent restlessness of nature, is the resultant of mutually interacting parallelograms of force, cancelling and compounding velocities, continuing through an indefinite expanse of space and time. But at this level we are dealing with resultant effects. The real problem takes its origin in the situation which may be stated as follows: granted that electrons have attained the status of "electronicity," why should they aspire to the level of atomic behavior? And how did the microscopic activities of atoms ever get unified by a macroscopic rhythm which summarized the random behavior of atoms into the mode of events having the property of mole-

cularity? And we might continue to raise the same question at each level of nature where evolution takes a new direction.

A once-favored mode of explanation (now regarded as a form of obscurantism), proceeded by invoking a special force or "principle" to perform the necessary function. We no longer attribute the action of a soporific to its "dormific" power, but we still hold that aggregates of matter, like a globule of mercury, tend, under the influence of "cohesive forces," to assume a geometrical form in which the external bounding surface is spherical in shape because the sphere has the mass-surface ratio at a maximum. Thus, we argue, arises the property of surface tension, in which the outer membrane or layer of molecules acts as a tight skin. Another attractive explanation, similar to the preceding, may be set forth as an illustration of what is still considered a valid type of theory.

If one take a number of balls and arrange them in various possible geometrical patterns, it will be found that there is no conceivable arrangement of spherical objects in space loci which will yield both maximum density and universal symmetry. Nor have physicists ever found an equation for such a configuration. With these facts as a premise one might arrive at the facile conclusion that matter or "behavior-stuff" is active because it is eternally forced to seek to attain a status of equilibrium between density and symmetry which is geometrically, and hence physically, unattainable.

This is perhaps as good an explanation as can be given at present. Certainly, when one considers that the same formula, that the attraction ("cohesive" power) varies inversely as the square of the distance, holds for magnetic attraction, as well as for gravitational pull, and that this same geometrical relationship underlies the variation of intensity of light or sound with variations of distance, we

are forced to conclude that geometrical relations (mass-surface ratios, etc.) are most important. Indeed, the very argument I am setting forth affirms that integration and disintegration are aspects of a self-contained, curvilinear or spatially closed universe, and that in this sense the geometrical relations between a sphere, its radius of curvature, and the contained mass, which is the basis of the inverse square law, is a causal factor in the synthesis of behavior-stuff. Nevertheless, the proper scientific attitude seems to me to be that of insisting that the forces of integration are still to be revealed. It is doubtful whether we can attribute causal efficacy to mere geometrical relations or mathematical abstractions, and I therefore urge that cohesiveness must be sought in the energy-flux created by the stresses and strains of the interlacing fields of force of the constituents of the cohering substances.

Reverting for a moment to the mass-surface ratio and the inverse square law, we may suppose that matter is a product, generated in the field of force, which propagates a radius of activity in accordance with the mass m, and that, therefore, *the sphere of action of material integration is defined by the field* $m/4\pi r^2$. Ultimately, the whole space-time continuum, or the cosmic field of energy, is implicated in the synthesis of behavior-complexes, or as the relativists say, action is the curvature of the world. Evolution, then, is the movement towards the higher modes of behavior which express the necessity of organizing whirls of micro-events into the unified macro-events which have been termed macroscopic rhythms. *The formula for integration is that the evolution of behavior-stuff expresses the tendency to increase to an optimum the activity coefficients of the bound energy patterns of which living and non-living matter is constituted.* The differences of potential created by these higher dynamic syntheses or labile equilibria represent the moving compromises of material

organizations in their respective fields of energy, all of which is an expression of the effort of the macro-cosmic field of energy to reach an equilibrium condition which is forever unattainable. This sounds as if the universe were in a bad "shape." But with this very general, abstract, and perhaps obscure formula we must rest content.

Protoplasmic Synthesis

In spite of the increased mass of facts which workers in the biological sciences have accumulated it is doubtful whether we have approached any nearer to the understanding of the true nature of organic phenomena. Time has only brought to light new "vistas of mechanism," which, in turn, require explanation. After stating what seems to be the underlying problem the present writer wishes to propose a theory for the consideration of those who may find in it some clue to a solution of the mystery of vital processes.

The organism is a relatively stable unity of diverse chemical transformations interacting upon each other. Yet through all these varied reactions certain *normals* (as J. S. Haldane terms them) are maintained. This is the phenomenon of "control," "regulation," "the unity of the organism," etc. As W. E. Ritter states it, the organism in its totality is as essential to an explanation of its elements as its elements are to an explanation of the organism.

Such terms as *organicity* and *organization* have been coined to express the fact that the whole of the organism seems to act in the unit parts, in development following upon the combination of genetic units in fertilization, as well as the balancing of the processes within the organism to each other, and in the adjustment of the organism to its

external environment.[12] The problem of the unity and individuality of the organism is that of describing how these heterogeneous physiological processes of what E. B. Wilson calls a "polyphasic colloidal system" are integrated. To be sure, the biologist is not wholly at sea in this matter of regulation. The growing insight into the importance of the role of *vitamins, hormones,* and *enzymes* has opened up new fields of investigation into the matter of chemical regulation in organisms.[13] But like the discovery of radioactivity, this has only removed the difficulty one step. The uncovering of the energetic processes (releases of stored energy which make the organism an equilibrium under stress), involved in these biochemical catalyzers resembles not a little the revelation of intra-atomic energy content which followed upon the discovery of radioactive transformations. In the face of such amazing discoveries it still remains true that about all that can be stated concerning the problem of control has been summed up by Professor F. W. Gamble in his Toronto (1924) address: "The infinitely varied animal fabric appears to be the exquisitely balanced individual expression of processes that quicken and restrain."

And how are we to understand these mutual interlockings of drivers and restrainers within protoplasmic systems? Can the analogy of the physical relation between the field of electromagnetic energy and the discrete entities of material aggregates be of any service in understanding the functional unity of organisms? The present writer seriously entertains the belief that the relation between matter and the field is a true homologue of the relation

[12] O. L. Reiser, "Life as a Form of Chemical Behavior," *Monist,* Vol. 34, pp. 150-160.

[13] Dr. Edwin E. Slosson, to whom I am indebted for several references, informs me that the trend of experimental work is to show that the vitamin is not so much a chemical compound as a center of ultra-violet radiation. This seems to me to confirm to some degree the theory of things for which I am arguing.

between the discrete structures of complex organisms and the unitary character of the responses which have puzzled workers in physiology and psychology. This view strikes me as inevitable because, I repeat, the notion of "empty" space (which, for instance, separates the components of cell tissues), is as useless precisely to the extent that it is vacuous, and, moreover, because biochemical reactions would be impossible if it were not for the radiant energy in which **all matter is immersed.** Should anyone fear that the hypothesis I am proposing is too wild I may refer to J. B. S. Haldane's *Daedalus* and A. P. Mathews' essay in *General Cytology* ("Some General Aspects of the Chemistry of Cells") as illustrations of the metaphysical extremes to which supposedly hard-headed men of science may be driven in their speculations.

Accordingly, the present writer[14] postulates that every atomic fact of nature, from an electron to the quantum of nervous energy (an "all or none" pulse[15]), is but the visible sector of an environing field of force (a cross-section of the cosmic curve of action), which determines what kind of material configuration or bound energy pattern can be further assimilated to this stress-center. The development of organisms, as complexes of differentiated structures integrated into functionally coördinated systems of responses is guided by the developmental possibilities from which morphogenetic forces must select their patterns to weld on to the original complex. *This conception of tensions in the interlacing fields of force as the basis of the pathways constituting "growth potentials" or "physiological gradients" for the specialization of tissue holds out an explanation of the structural-functional evolution of organic forms in exactly the same fashion as it does in the inorganic realm.*

[14] "A Monism of Creative Behavior," *Journ. of Phil.*, Vol. 21, 477-492.

[15] The present writer has discussed briefly the "all or none" law in psychology in "The Synthesis of Mind," *Journ. of Phil.*, Vol. 21, pp. 281-294.

The essentially electromagnetic character of the processes of cell division are generally recognized in all theories which ascribe the physico-chemical state of the protoplasmic colloids to the hydrogen ion concentration of the medium. The electrical character of biological phenomena is evident in (*a*) all speculations concerning the effect of the electric charge upon the rate of passage of ions through membranes; (*b*) the dependence of the change of state in nerve or muscle, from rest to excitation, etc., upon changes in ionic concentration of the cells (suggested earlier by J. Loeb and Nernst, and more recently by R. S. Lillie, Lazareff and L. T. Troland); and (*c*) theories which locate protoplasmic synthesis at the iso-electric point in the cell proteins. Parenthetically, it may be remarked that a "monism of action" faces the problem of the "origin of life" only in the sense that the conditions for the synthesis of the organic colloids must be determined. According to Pflüger the fundamental difference between living and non-living colloidal aggregates lies in the fact that the living proteins of protoplasm contain a cyanogen group as a part of their molecular composition. None the less, I still insist that the radiant energy of the field in which protein molecules operate can not, in the last analysis, be completely ignored, and I can not, therefore, overlook the opportunity of pointing out that we may obtain some notion of how "life" may have taken its origin in the sea from the work on the formation of formaldehyde and the sugars *by the action of light of short wave length* on carbonic acid and water.

Although electrical theories of living matter have attracted many speculators, only one investigator[16] has specifically sought to correlate the similarity of colloid, enzyme and catalytic action with electromagnetic phenomena.

[16] N. E. Dittman, "The Electromagnetic Nature of Colloidal, Enzyme and Catalytic Action," *Science*, N. S. Vol. lx, p. 183.

Within more restricted limits H. Graham Cannon[17] has sought to envisage the "nature of centrosomal force" through an electromagnetic outlook, and Geo. W. Crile[18] has admitted the electromagnetic correlate to the chemical processes resident in nerve tissue activities. The present writer would sweep all these ideas together under the thesis that differentiation of structure in evolving behavior-complexes has taken place along the physiological gradients as determined by the differences of potential within the *action currents* deposited by the fields of force effective in the synthesis of all material configurations, whether the space-lattice arrangement of atoms and molecules in crystals or organic cell-groups. This action of radiant energy on matter is always specific—to be understood perhaps as a syntonic or resonance effect—and it is therefore probable that frequencies which eluded the sensory analysis of primitive organisms have been active in the synthesis of receptor-conductor-effector mechanisms. In vision light has helped to build up the light sensitive elements of the retina, and, on the whole, the evolution of vision has gone in the direction of providing a mechanism for the sharpening of the meniscus between matter and the field, so that bodies take on sharper outlines.

As the present writer[19] has intimated, the best biological explanation of the hierarchy of reactions underlying the synthesis of responses is presented by Charles M. Child's hypothesis of metabolic gradients. In the following section I wish to expand this suggestion.

[17] *The Journ. of Genetics*, Vol. 13, pp. 47-79.

[18] "A Suggestion as to the Mechanism of Memory," *Journ. of Comp. Psychol.*, Vol. i, 1921, pp. 201-211.

[19] "Behaviorism as a Monism of Action," *American Journal of Psychology*, Vol. 34, 1924, pp. 545-559.

Child's Hypothesis of Metabolic Gradients

According to Child's hypothesis, in Planarians the intensity of chemical change tapers off from the head end of the organism, where the processes of life are the most active, towards the lower metabolic potential of the tail, and that in asexual reproduction the organism divides transversely at the point near the secondary apex, where the metabolic gradient again picks up. Now the point in this which I wish to elaborate lies in the doctrine that levels of higher energy potential dominate those of lesser metabolic rate. How can this be explained?

As Professor Child argues in his *Individuality in Organisms* (1915), the origin of physiological individuality is to be found not in living protoplasm alone, but in the relation between living protoplasm and the external world (p. 41). The primary effect of the stimulus on undifferentiated protoplasm is the increase of the metabolic rate at the point excited. This stimulus is transmitted as a dynamic change over the protoplasmic mass, perhaps by a wave-like irradiation, which undergoes a decrement of intensity in its course. The result of continued or frequently repeated excitation "is the establishment of a gradient in the protoplasm, which constitutes a more or less permanent material substratum for a persistent metabolic gradient independent of the local external stimulus" (p. 34). "A relation of dominance and subordination exists between the level of the highest and the levels of the lower metabolic rate" (p. 36). These metabolic gradients or axes of polarity and symmetry are the expression of physiological unity and order, the starting point of organization, and the factors in determining growth and differentiation.

The notion of physiological gradients, I take it, is analogous to the conception in physics of differences of electrical potential. The physiological gradient of nervous tissue is the condition for the conduction of nervous impulses as waves of ionization. Here a definite electrical basis is attributed to the passage of the wave of excitation. But the real nature of the nerve impulse is still something of a mystery. According to the Nernst-Lillie[20] theory it consists in the propagation of a series of action currents considered as pulses of depressed polarization and increased permeability, travelling along the membrane surrounding the conduction pathways.

I do not see that there is any necessary conflict between this view and Child's theory of metabolic gradients. For that matter, Child argues in his more recent books that the nervous system does not represent a new integration somehow imposed upon primitive protoplasm, but rather a product of the primary integrating factors (chemical control, etc.) which make the organism an orderly whole. However, the quantitative expressions for this whole field remain to be worked out in detail, and the present writer looks forward to the time when someone with the necessary technical equipment (another Jacques Loeb) will attain the synthesis.

The Unity of Mind

A final word as to the psycho-biological implications of this theory. The principle of a hierarchy of levels of synthesis introducing unity of action through the relation of dominance and subordination between the integrating mechanisms of those seats of energy flux we call organisms is being recognized on all sides. C. S. Cherrington credits

[20] "The Relation of Stimulation and Conduction in Irritible Tissues to Changes in the Permeability in the Limiting Membranes," *American Journal of Physiology*, Vol. 28, 197ff.

Hughlings Jackson with having first pointed out the significance of levels of neural machinery standing in the relation to each other of drivers and restrainers. It is in this relationship, as Dr. W. H. R. Rivers suggested, that the explanation of *facilitation* and *inhibition* (or what Dr. H. Head terms "vigilance") is to be sought. The "repressions" exercised by the "psychic censor" are nothing more than this process whereby a reaction of a lower level is modified by one of a higher level of activity.

So far as the unity of mind is concerned, it may be argued that the relation between the unity of consciousness and discrete neural impulses is analogous to, if not identical with, the relation of an electron to its environing field of energy, and that mind is the unitary mode of behavior towards which neural pulsations strive to integrate themselves. This view recommends itself to me because it provides a resolution of a certain dilemma centering around one of the crucial issues of modern psychology. Dr. K. S. Lashley[21] has pointed out that the dynamic conceptions involved in the doctrine of the libido, psychic censor, and other mechanisms essential to the explanation of repressions, sublimation, etc., resemble more closely the behavior of liquids under pressure than they do any recognized physiological processes. He therefore dismisses these psychohydraulic analogies, arguing that the *neurine* of Wm. McDougall and D. F. Harris, the "damned up" energy of R. S. Woodworth, and the *drainage* hypothesis of Max Meyer are not in harmony with recent work on the propagation of the disturbance in nerve fibres.

Admitting the difficulties involved in the conception of nervous and mental "energy," it seems to me that, whatever our theory of nerve transmission may be (whether the Nernst-Lillie theory or the conception of Prof. L.

[21] "Physiological Analysis of the Libido," *Psychological Review*, Vol. 31, pp. 192-202.

Lapicque), the way should not be closed to the psychohydraulic analogy. There are many cases in physics where the macroscopic effects bear the same relation to their elementary constituents as a fluid to its discrete units. The perceptually continuous frequently breaks down into the conceptually discrete. As Professor G. N. Lewis[22] points out, the mathematics of hydraulics is based on the theory of the continuum. It is admirably fitted to express the behavior of substances like water and air. "Nevertheless the method is entirely an approximate one, for water and air are not continua, but are composed of discrete molecules." Hydrodynamics is unable to account for such phenomena as Brownian movements. The kinetic theory of gases affords another illustration of a corpuscular theory; and yet if the movements of the individual molecules are averaged the pressure is continuous. Now if a discrete theory of matter is useful for certain purposes and a continuous theory may be employed for others, why should we not entertain a psychohydraulic conception of mind, if the empirical analysis reveals that a fluid theory or a doctrine of elasticity requiring a mathematics of the continuous is more in accordance with the facts?

The methods of hydrodynamics, as Professor Lewis states, were carried over into the field equations of electromagnetics. Is it not conceivable that the discrete character of the functional and anatomical units of the brain enter into the continuum of mental life in the same fashion? The doctrine that discontinuous impulses pour into the cerebrum from the various sensory channels and establish a relatively constant equilibrium comparable to a level of pressure in a fluid reservoir seems to me to be a tenable doctrine. *Muscle tonus* would be both a cause and an effect of this synthesis of shifting neural tensions. Conceived as an elevation or dropping down to various levels of psycho-

[22] *Valence and the Structure of Atoms and Molecules*, 1923, Ch. xiv.

neural energy, this view presents a workable theory of the facts of normal and abnormal conduct.

Professor Montague has argued that consciousness is potential energy. He supposes that the synapse acts as a kind of trap wherein the kinetic energy of the nerve impulse is transformed into potential energy. Assuming that energy is a reality (in spite of the fact that it may assume a negative value), I believe that Professor Montague would, if pressed, be forced to concede that since potential energy is energy of the aether (as Sir Oliver Lodge insists), consciousness must exist as a kind of peculiarity in structure in such an aether as the physicists will allow us. Mental life is a continuum because, relative to matter, the fields of force in the aether form a continuum in the same way that a fluid acquires the property of an elastic medium.

How purposive behavior is to be fitted into this scheme as a special case of "control of the present by the future" I have tried to show elsewhere.[23] Conscious purpose is the echo in the organism of the universal biological demand for unitary behavior. Just as molecularity is a "quality" of atomic configurations, and life is a quality (functional unity) of protoplasm, so mind is a quality (dynamic synthesis) of sensori-neuro-muscular-glandular events.

I do not wish to underestimate the difficulties of developing a tenable theory of reasoning,[24] but a new theory of *things* will, I believe, go a long way towards solving the so-called mind-body problem.

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[23] "Creative Monism," *Monist*, Vol. 34, pp. 395-426.

[24] See the present writer's, "The Structure of Thought," *Psychological Review*, Vol. 31, pp. 51-73.

INFINITY AND THE INFINITESIMAL

It is not needful to enter into disputes regarding the infinite, but merely to hold all that in which we can find no limits as indefinite. . . . We will accordingly give ourselves no concern to reply to those who demand whether an infinite number is even or odd, and the like, because it is only such as imagine their minds to be infinite who seem bound to entertain questions of this sort.—*René Descartes.*

I protest against the use of infinite magnitude as something completed.—*Karl Gauss.*

There is no actual infinity.—*Henri Poincaré.*

To say an aggregate . . . is infinite is often an important step; but often it is only the first step. To penetrate farther into the problem may require us to state *how* infinite. . . . The honor of having done this belongs to Georg Cantor.—*James P. Pierpont.*

Except in regard to such matters as Cantor's theory of infinity no finality is claimed for the theories suggested.—*Bertrand Russell.*

It is known that infinities rise above infinities in a summitless hierarchy.—*Cassius J. Keyser.*

PART I

Introduction

THERE is probably no word so frequently and so carelessly used, both in philosophical and in mathematical discourse, as the first which appears in the title of this paper; and if there is another, infinity merely divides honors with infinitesimal. We therefore believe that, since these two words have sown nearly as much faulty logic in the fields of mathematics and metaphysics as all other words put together, they should be rooted out of both the fields which they have contaminated. And not only should

they be rooted out, lest more errors be propagated by them: a due amount of salt should be ploughed under the infected territory, that the damage be mitigated as well as arrested.

It is difficult to estimate, without seeming to exaggerate, the damage for which these two terms are responsible. This damage is intense in spots; elsewhere it is less violent but more extensive. Indeed, the popularity of the word *infinity* is not unlike an intermittent and peripatetic fever, breaking out now in one country and era, perhaps leaping some time and some territory, and then returning with increased severity to its origin. A single thinker, in fact, may be so affected. Descartes, for example, uses the word unguardedly, not only in his *Géometrie* but in many of his philosophical works, although in *Principia,* i, xxvi-xxvii, he roundly repudiates it. Like instances are remarkably numerous. That a writer denounces the term in one of his works is no guarantee that he will denounce it in another. Moreover, in the face of his denunciation which may be consistently vehement, some other writer, paying tribute to his predecessor's eminence, will coolly go his own way, neither refuting nor even mentioning these earlier arguments. The consequence, naturally enough, is a surplus of contradictions and confusion. Infinity is a legitimate term, a valid name for an unimpeachable process; infinity is a meaningless noise, translatable into more gibberish at pleasure. Which definition will you have? According to the implicit if not explicit attitude of many contemporary mathematical logicians, you may have both: successively if you are bright, simultaneously if you are positively brilliant.

We are not unaware of past efforts to clarify the concept of the infinite—of efforts to determine, indeed, whether there be anything at all to this concept besides a word that will survive the hardest usage. We are, as a matter of fact, so alive to these labors as to be little sanguine, in

view of their reception, of any success in trying to further them. Yet it still may be that arguments ignored by our contemporaries will win a hearing if restated in modern language, and if placed forcibly in juxtaposition with their own doctrines. Furthermore, as we have said, those who have contended against infinity have not been invariably consistent· nor have they perhaps, when consistent, entered adequately into the psychological basis of the notion. It is obvious that a word as popular as is infinity must borrow its vogue and vigor from strong emotion. What is this emotion, what is the mental habit of men, that makes them demand a term without being able to rationalize or to justify their craving? The answer, we believe, is to be found in no department save psychology. We have, therefore, in the second part of the following study, looked carefully over this psychological background. But before doing so we have deemed it wise to examine, on their own ground, the infinitists' arguments for an "infinite number." The formal mathematical thus precedes and introduces the broader psychological study, which itself is intended not only to clarify this earlier technical treatment but also to emphasize the necessity of viewing the principles of logic as anterior to those of mathematics—an approach that Jevons (unhappily with little company today) insisted could never be flouted with impunity.[1]

[1] W. S. Jevons, *The Principles of Science*, 1887, Bk. II, Chap. VIII. Jevons' remarks on this point are so apposite, and so seldom echoed by contemporary writers, that we may be pardoned for copying a few of them:

"I cannot assent, indeed, to the common notion that certainty begins and ends with numerical determination. Nothing is more certain than logical truth. The laws of identity and difference are the tests of all that is certain throughout the range of thought, and mathematical reasoning is cogent only when it conforms to these conditions, of which logic is the first development. And if it be erroneous to suppose that all certainty is mathematical, it is equally an error to imagine that all which is mathematical is certain. . . . In fact, we no sooner leave the simple logical conditions of number than we find ourselves involved in a mazy and mysterious science of symbols. . . . When simple logic can give but a bare answer, Yes or No, the algebraist raises a score of subtle questions, and brings out a crowd of curious results. The

With the destruction of the validity of the infinite, it seems almost unnecessary to add, all the validity of the infinitesimal vanishes. Since Berkeley and Weierstrass the latter concept has been widely repudiated, by metaphysicians and by mathematicians respectively. Curiously enough, however—and this is but another commentary on the agility of contemporary thinkers—the infinite is not thereby believed affected. On this account, and to make our survey the more comprehensive, we have examined part of the history of the infinitesimal, pursuant to our technical study of the infinite and as an introduction to our psychological summary of the whole problem. By briefly rehearsing the tale of a concept that was once deemed indispensable, but is now admitted not to be, we thus show that a mathematical notion which is logically vicious and repugnant to common reason has been in the past, as we hope one like it will be in the future, spewed out as amorphous nonsense.

II

SALVIATI: I suppose you know which are the square Numbers, and which not?

SIMPLICIUS: I know very well that a square Number is that which arises from the multiplication of any number into itself; thus 4 and 9 are square Numbers, that arising from 2, and this from 3, multiplied by themselves.

SALVIATI: Very well; and you also know, that as the Products are call'd Squares, the Factors are call'd Roots: and that the other Numbers, which proceed not from Numbers multiplied into themselves, are not Squares. Whence taking in all Numbers, both Squares and not Squares, if I should say, that the Not Squares are more than the Squares, should I not be in the right?

SIMPLICIUS: Most certainly.

* * * * *

flower and the fruit, all that is attractive and delightful, fall to the share of the mathematician, who too often despises the plain but necessary stem from which all has arisen. In no region of thought can a reasoner cast himself free from the prior condition of logical correctness. The mathematician is only strong and true as long as he is logical, and if number rules the world, it is logic which rules number."

SALVIATI: But now, if I should ask how many Roots there are, you can't deny but there are as many as there are numbers, since there's no Number but what's the Root to some Square. And this being granted, we may likewise affirm that there are as many Square Numbers as there are Numbers; for there are as many Squares as there are Roots and as many Roots as Numbers. And yet in the beginning of this, we said, there were many more Numbers than Squares, the greater part of Numbers being not Squares. . . .

SAGREDO: What must be determined then in this case?

SALVIATI: I see no other way, but by saying that all the Numbers are Infinite; Squares are Infinite; their Roots Infinite, and that the Number of Squares is not less than the Number of Numbers, nor this less than that.

The foregoing dialogue[2] is, with little question, the most delightfully lucid *reductio ad absurdum* of the doctrine of infinity extant. Despite its having been put forward, ostensibly in all earnestness, by the foremost thinker of his age, Galileo's demonstration of the infinity of numbers half inclines one to the suspicion that he was indulging a scholarly jest. Whether intended as a witticism or as an argument (and the context really prevents our treating it as the former), it is lamentably certain that the conclusion at which Salviati arrived four hundred years ago is today accorded an amazing amount of respect.

Although no less a mathematician than Karl Gauss, and as long ago as 1831, handed down his indictment of the general use of the word "infinity," neither the weight of his authority nor the length of time it has been impressed on the world, has sufficed to rid mathematical philosophy of this abjured and meaningless term. "I protest," he wrote,[3] "against the use of infinite magnitude as something completed, which in mathematics is never permissible. Infinity is merely a *facon de parler*, the real meaning being a limit which certain ratios approach indefinitely near,

[2] Galileo Galilei, *Dialogues Concerning Two New Sciences.* Translated by Thomas Weston, London, 1730, First Day; National Edition, edited by A. Favaro, pp. 78-9. A new and more literal translation has been made by Henry Crew and Alfonso de Salvio, N. Y., 1914.

[3] *Werke*, Bd. 8, 216.

while others are permitted to increase without limit." That his protest had little beneficial effect is, however, painfully clear, in that its most immediate consequence was to stimulate Georg Cantor in his attempted demonstration of the strict validity of the term which his great predecessor had openly proscribed. And Cantor's obstinacy by no means terminated with his own work: it has been transmitted to a great number of his successors. "Infinity" is a word appearing on nearly every page of the considerable literature he directly or indirectly inspired. It is a word the ignoring of which by applied mathematics has, one might say, simply increased its popularity with the theorists. Its very ostracism seems to have afforded it dignity, its isolation being interpreted as grandeur.

That a word or symbol, which, standing for so vague a notion as the infinite, yet appears continually in works professedly logical—works that aim, indeed, at the purification of logic—is an anomaly of no mean importance to an understanding of the logical basis of modern reasoning in relation to the structure of mathematics. We see at once that attacking infinity is by no means digging up a dead horse in order to flog it, when we come to examine the work of Dedekind, Cantor, Frege, Hobson, Russell, Whitehead, Pierpont, Keyser, and their followers, and observe the frequency with which this hypnotic term is shamelessly invoked.

That Galileo's dilemma, given above, implies untenable contradictions, has often been remarked by his successors. The solutions offered have, however, exhibited a diversity equalled only by their number, and as remedies have been even worse than the disease. Among the most recent of alleged cures is that based on the Cantorian infinite, and summarized by Mr. Russell as follows:[4] "The way in which

[4] *Our Knowledge of the External World as a Field for Scientific Method in Philosophy*, by Bertrand Russell, 1914, pp. 194-5.

the problem is expounded is worthy of Galileo, but the solution suggested is not the right one. It is actually the case that the number of square (finite) numbers is the same as the number of (finite) numbers. . . . But although the infinite numbers which Galileo discusses are equal, Cantor has shown what Simplicius could not conceive is true, namely, that there are an infinite number of different infinite numbers, and that the conception of *greater* and *less* can be perfectly well applied to them. The whole of Simplicius' difficulty comes, as is evident, from his belief that, if *greater* and *less* can be applied, a part of an infinite collection must have fewer terms than the whole; and when this is denied all contradictions disappear." As well they might, we add, for this is homeopathy with a vengeance.

III

Modern mathematical philosophers, writing of the "true" or "proper" or "completed" infinite (the Cantorian infinite as distinct from the conception indicated in the preceding passage from Gauss), exhaust their powers in attacking the contradictions so freely engendered by that doctrine. These "apparent" contradictions they attribute to our intellectual distrust of novelty, to our deeply rooted habits of thought, to our confusion of the essential with the accidental in our conception of number. And that we suffer sadly from these failings, the more frank among us are disposed freely to admit. We think back to those unfortunate creatures condemned by philosophers to hang on by their toes at the antipodes, to the *actio in distans* dilemma, and to other foibles of the scientific mind, peering out incredulously from behind its trenchwork of Inconceivability. Fear lest our best-founded doctrines prove but twentieth century foibles, and the subtlety of the Russellian pen, soon predispose us to accept the logical validity of the Cantorian

infinite, or, at any rate, to hold our objections to it in abeyance. But the subtlety is so exclusively lavished upon the alleged validity, that the concept for which this validity is insistently claimed, remains deplorably vague. Again and again we meet some such phrase as "Consider the series of all the positive numbers" or "Consider all the fractions less than 1." Consider them? For the life of us we can not. We can consider any number of them, but not *all*. For, clearly, there is no *all* to be considered.

Long ago James Mill pointed out that having successively the sensations of green and red, and knowing them to be different, are not two things but one and the same thing.[8] At this early stage in the individual's experience the concept of number must have its genesis. For having successive sensations of green and red, and knowing them to be different (knowing them to be *two*), involves, of course, an adumbration of the number-concept *two*. In some such way, we have no doubt, arose the series of ordinal numbers. Although the writers are well aware that there are those who would reverse this analysis and derive the ordinal numbers from the cardinal, they believe this to be a cardinal error, resting its plausibility solely upon the premisses implicit in a realistic attitude. For in addition to the authority of such mathematicians as Cayley, Helmholtz, Kronecker, and even Dedekind (a veritable pillar of the Transfinite Church of Continuity), all of whom regarded cardinal numbers as derived from the ordinal series, we have evidence more weighty in the testimony of an ethnologist: "Ordinal numbers are generally derived from cardinal numbers, as *third, fourth, fifth,* from *three, four, five.* But among the very low ones there is to be seen evidence of independent formation quite unconnected with a conventional system of numerals already

[8] James Mill, *Analysis of the Phenomena of the Human Mind,* Vol. I, Chap. V, and Vol. II, Chap. XIV, Sec. II.

existing. Thus the Greenlander did not use his 'one' to make 'first,' but calls it *sujugdlek,* 'foremost,' nor 'two' to make 'second,' which he calls *aipa,* 'his companion'; it is only at 'third' that he takes to his cardinals. . . . So in Indo-European languages the ordinal *prathamus,* πρῶτος, *primus, first,* has nothing to do with a numerical 'one,' but with the preposition *pra,* 'before,' as meaning simply 'foremost'; and although Greeks and Germans call the next ordinal δεύτερος, *zweite,* from δύο, *zwei,* we call it 'second,' Latin *secundus,* 'the following' (*sequi*), which is again a descriptive sense-word." [6] On evidence such as this, and more is easily procurable by him wanting it,[7] a safe inference may be drawn that the more concrete ordinals preceded the more abstract cardinal numbers, and that the so-called number-concept is a subsequent and convenient generalization based on the verbal description of acts, rather than contrariwise. Thus, if our analysis be correct, it was subsequent to the formation of the ordinal series that man observed that the foremost and the successive terms of different series of objects have the qualities of being *foremost, next-after,* and *next-after-next,* respectively, in common. From this recognition, by the familiar

[6] E. B. Tylor, *Primitive Culture,* Vol. I, pp. 257- 8. *Cf.* Chap. VII, *passim.*

[7] *E. g.,* L. L. Conant, *The Number Concept,* 1896, *passim.* Two centuries ago, Locke wrote: "He that will county twenty, or have any idea of that number, must know that nineteen went before, with the distinct name or sign of every one of them, as they stand marked in their order; for whenever this fails, a gap is made, the chain breaks, and the progress in numbering can go no further." (*Essay,* Bk. II, Chap. XVI, Sec. 7.) We can not forbear calling the reader's attention to the havoc this analysis of the relation between ordinal and cardinal number plays with the notion of an "infinite number." The infinitists, though firmly convinced of the reality of "aleph-zero," regard the existence of the corresponding ordinal as an open question. Few such writers, for reasons not difficult to suspect, are interested in ethnological facts; and when they do urge the consideration of these they confidently assume, and state with little fear of denial, that cardinals are probably reached prior to ordinals. Charles Emile Picard (*Congress of Arts and Science,* St. Louis, 1904, Vol. I, p. 498), rashly so appeals to primitive life.

process of generalization, arose the concept of the cardinal numbers.

We have so far traced the formation of the number-concept from its genesis in the recognition of, or distinction between, priority and posteriority, through the analysis of simple priority-and-posteriority into the more complex, yet still concrete, series of ordinal numbers. We have seen how, *by generalization,* the abstract cardinals have arisen, representing that which is common to all examples of "first-ness," "second-ness," etc. When the formation of number-concepts by the addition of one, has extended some little way, attention is called to the fundamental process of addition, and to its inverse, that of subtraction. It is observed empirically that two objects and two objects form an aggregate equal to that obtained by the thrice performed addition of one to a first unit. The notion of the inverse operation is, of course, analogously formed, as are the subsequent notions of multiplication and its inverse, division; the formation of powers and its inverse, the extraction of roots, etc.[8]

Now, everything written in derogation of our logical prejudices, be it repeated, we admit may be warranted. Moreover, we see no way of defending our notion that adding two positive integers together must produce a number larger than either of these, if a number can be found not subject to that general rule. We are therefore impelled to ask, What such number can be found? From the first page to the last in the writings of this school of mathematical logicians, no more convincing example of an "infinite number" is to be met with than the vague notion suggested by

[8] "The domain of the elementary operations in arithmetic is exhausted by addition and multiplication, including the inverse operations. . . . There are no other fundamental operations—at least it is certain that no example is known in analysis, where, if an analytic connection exists at all, this can not be analyzed into and reduced to those elementary operations." Weierstrass, quoted from Kossack by J. T. Merz, *History of European Thought in the Nineteenth Century,* Vol. II, p. 726, note.

the "consideration" of an unending series. Since it is evident that upon the right of the totality of the members of an endless series, to be considered a *number,* depends the validity of the doctrine of the "proper," or "completed" infinite, we are forced to inquire, first, whether it have a right so to be considered, and, secondly, whether the saying it has, merit even our tentative assent.

Let us therefore begin by closely examining some of the statements of Mr. Russell, whose indefatigable efforts to clarify mathematical concepts have placed him in the unenviable position of scapegoat for a large group of mathematical writers the ideas of whom, though sometimes not less faulty than his, are less open to attack, shielded as they are by obscurity.

The difficulties in Zeno's arguments against motion, says Mr. Russell,[9] "can be met if infinite numbers are admissible. . . . Consider, for example, all the fractions less than 1, arranged in order of magnitude." And again:[10] "The numbers before it [Aleph-zero, the smallest infinite number] form an infinite series, containing all the ordinary finite numbers, having no maximum, no last finite term after which one little step would plunge us into the infinite." And, in the next sentence but one: "The first infinite number is, in fact, beyond the whole unending series of finite numbers." Granting, for the moment, that there can be anything beyond an unending series (a claim believed by Mr. Russell and justified in an argument to be examined), it remains to be shown that, in this case, the hypostatized entity is a number. This Mr. Russell attempts to show by arguments singularly fallacious. So shadowy is this realm of Number, and so intense a degree of abstraction is demanded in its exploration, that methods the worthlessness of which would be at once apparent in another

[9] *Op. cit.*, p. 178.
[10] *Ibid.*, pp. 180-1.

science, here deceive not only their readers but their authors. Once they become entangled in the jungle of fallacies they have planted, they are in the rueful plight of the famed wanderers unable to see the forest for the foliage.

The view of numbers as generated by counting, has been, according not only to Mr. Russell, but to the majority of mathematical realists, the chief psychological obstacle to the understanding of "infinite numbers": "Infinite numbers can not be reached at all in this way," Mr. Russell, for example, remarks. "The mistake is of the same kind as if cows were defined as what can be bought from a cattle-merchant. To a person who knew several cattle-merchants but had never seen a cow, this might seem an admirable definition. But if in his travels, he came across a herd of wild cows, he would have to declare they were not cows at all, because no merchant could sell them. So infinite numbers were declared not to be numbers at all, because they could not be reached by counting." [11]

Now, if by any chance we were to happen upon a herd of "infinite numbers," doubtless we should feel a like embarrassment. We fear, however, that Mr. Russell is unable to drive a herd our way,—or even one solitary little calf (Aleph-zero). Were the difference between an "infinite" and a finite number no more fundamental than that between a wild and a domesticated cow, there would be little to dispute. But Mr. Russell's "wild cows" possess, in addition to their admitted wildness, attributes never before conjoined with those of that valuable creature. Not to dwell too long upon an unfortunate analogy, let us consider for a moment whether a zoölogist would or would not give the name "cow" to an animal possessing, in addition to merely transcendental wildness, a virtue by means

[11] *Ibid.*, p. 188.

of which it sets aside the alteration ordinarily consequent upon cutting it in two.

The fallacious argument alluded to above—the proof that there can be a number after an unending series—deserves the closest attention, for the exposure of this fallacy strikes, we are persuaded, at the foundation of the theory of "transfinite numbers." Consider, says Mr. Russell,[12] the number 1. It is beyond the unending series of fractions less than 1. There are as many fractions less than 1 as there are finite numbers less than Aleph-zero.[13] This analogy is, then, Mr. Russell's argument that there can be a number after an unending series. It is a *petitio principii* of the first order. For even if we did not have it from Mr. Russell's own pen that the concept of 1 is the logical basis of our conception of fractional quantities, the basis of the proof would still be void. A fraction is not the expression of a portion of a unit, but is the indication of a process, namely, division, and an expression of the frequency with which some unit (other than that formerly considered) is required by definition to be taken. A fraction *per se* is unthinkable; less than one *something* there is nothing whatsoever to be thought of. Mr. Russell, in his definition of a fraction ("We shall define the fraction m/n as being that relation which holds between two inductive numbers x, y, when $xn=ym$")[14] clearly states this indisputable fact, but in his proof of the existence of "infinite numbers" the definition, strangely enough, is forgotten. The difficulty invites a colder analysis.

Suppose, then, for illustration, we again take our friend the cow, letting her serve as our symbol of unity. Of a herd this cow would represent a fraction, just as a rib of

[12] *Ibid.*, p. 173.

[13] *Vide Ibid.*, p. 179: ". . . the total number of fractions less than 1 is infinite. . . . Etymologically 'infinite' should mean 'having no end.' But in fact, some infinite series have ends, some have not."

[14] *Introduction to Mathematical Philosophy*, 1919, p. 64.

beef might be called a fractional cow. In other words, we could say 1/20 herd=1 cow, and 1/20 cow=(say) 1 fine large steak. Apparently we have here an absolute fraction. But a *real* fraction (*i. e.*, of a unit), we see on closer inspection, has escaped us. What has taken place, all that truly has happened, in reaching this pseudo fraction, is the substitution of a new unit for our old one.[15]

That this analysis is both vitally important to the logical interpretation of quantity and extremely awkward for Mr. Russell's argument, we think an irrefragable conclusion. For if, as we have seen, the concept of 1 is admittedly the basis of the conception of fractions, the so-called fraction of a unit is simply a convenient expression of the number of times some given quantity is required to be taken. When, therefore, one endeavors, by means of an analogy based on the fractional series, to demonstrate that a number can come after an endless series, one begs the question. *For the proof that there is a number beyond all the finite numbers (Aleph-zero) is based on the assumption that there is a number greater than the greatest number that can appear as the denominator of a fraction (the very statement to be proved).* Such an argument is damned by the very words in which it is stated; and we hazard the dogma that it will never be salvaged until the infinitists contrive to show that the concept of Aleph-zero is the basis of our conception of the finite numbers.[16]

[15] *Cf.* Sigwart, *Logic*, 66, 14.

[16] Some, indeed, say so, but take remarkably small pains to show so. "The idea of the infinite is certainly a simple idea, as natural to the mind as any other, and even an antecedent condition of the idea of the finite." (Hackley, *Elementary Course of Geometry. Vide* Bledsoe, *Philosophy of Mathematics*, 1874, pp. 19ff.) The infinitists have attempted, without much success, to revive a similar theory. *Vide* Poincaré, *Science and Method*, n. d., p. 144, for a salvo of scorn against these efforts which he calls "pathological"; but compare E. B. Bax in *The Real, the Rational and the Alogical*, 1920, p. 243, for another attempt to resuscitate this notion of the infinite and put a galvanized ghost in command of philosophic speculation. C. J. Keyser (*Bulletin of the American Mathematical Society*, Vol. IX, May, 1903, and *The Human*

Significant as is the blunder just examined—so significant indeed as to cast a shadow of suspicion upon every statement in regard to infinities, made by him who has committed and published it—Mr. Russell would probably retort that we have attached too much weight to a mere analogy. His real proof of infinity rests with Cantor. Although we fail to see the value of an analogy that collapses the moment it is pressed, and though we are unable to understand where the legitimacy of an illustration resides if any fable can be adjourned when shown awkward, the hypothetical rejoinder shall be honored. If, as Mr. Russell solemnly avers,[17] Cantor holds the true key to infinity, it is obviously to him and not to his henchmen that we must address our request for admittance into the magic chamber of transfinities.

IV

Cantor defines, with the singular lucidity with which his mind can, on occasion, operate, an "Aggregate" as fol-

Worth of Rigorous Thinking, 1916, pp. 157, 159) likewise comes to the support of this endeavor, appealing to what he terms the "axiom of infinity" as a "necessary presupposition of both conception and inductive inference." However, it is interesting to observe and only fair to note here, in view of some strictures we shall pass presently upon Professor Keyser, that he carefully repudiates every extant "proof" of the infinite. His own words, showing in how sad a disagreement amongst themselves are the transfinitists, require being quoted, however briefly: "Candour compels me to assert . . . not only that the arguments which have been adduced (in proof of infinity) are all of them vitiated by circularity, but that in the very nature of conception and inference, by virtue of the most certain standards of logic itself, every potential argument . . . is foredoomed to failure, destined before its birth to take the fatal figure of the wheel. . . . The fact is that a more beautiful circle than his (Dedekind's) is hardly to be found in the pages of fallacious speculation . . . though it must be frankly allowed that Mr. Russell's more recent movement around the same center is equally round and exquisite."

[17] "Except in regard to such matters as Cantor's theory of infinity, no finality is claimed for the theories suggested." This example of unwarranted modesty is from the Preface to *Our Knowledge of the External World*, already quoted—a work in which there are advanced many theories, some wild like the cows, some domesticated, the least of which is more worthy of the claim to finality than Cantor's amazing fiction.

lows: "A collection of definite distinct objects which is regarded as a single whole is called an aggregate." [18] This definition of an aggregate, states Hobson,[19] "implies that the elements of an aggregate are logically prior to the aggregate itself. The *definite* and *distinct* [italics Hobson's] objects are, by an act of synthesis, regarded as a single collection, or aggregate." But when we come to consider an "infinite aggregate," where, we perhaps may be permitted to inquire, are we to find such an act of synthesis, when it is admitted on all hands that no act of synthesis, or repetition of such act, will yield the infinite?[20] We thus have, at the very portal of Cantor's construction, a contradiction so flagrant that many mathematicians, rather than attempt the reconciliation of statements so repugnant, have openly denied Cantor's fundamental definition, and have propounded a theory built upon a view of the relation of an aggregate to its elements the very inverse of that implied by Cantor's "synthetic definition," [21] while yet shamelessly availing themselves of results deduced by Cantor and others from the definition quoted above, a premiss which they deny.

Of Aleph-zero, the smallest "transfinite number," Cantor writes:[22] "The first example of a transfinite aggregate is given by the totality of finite cardinal numbers ν; we call

[18] E. W. Hobson, *The Theory of Functions of a Real Variable*, 2nd Ed., Vol. I, p. 189. Cantor's original definition was given in *Math. Annalen*, Vol. XLVI, p. 481.

[19] *Loc. cit.*, p. 235.

[20] Russell, *Introduction to Mathematical Philosophy*, pp. 78ff.; *Our Knowledge of the External World*, pp. 195ff.

[21] *Loc. cit.*, pp. 236-7.

[22] *Contributions to the Founding of the Theory of Transfinite Numbers*, by Georg Cantor. Translated, with an Introduction and Notes, by Philip E. B. Jourdain, 1915, pp. 103-4. Wherever the reference is to the Introduction, Jourdain is, of course, the authority. In many cases, however, the passages in the Introduction referred to are direct quotations from other labors of Cantor. These we have indicated, in order to avert confusion on the reader's part as to whether we are relying upon a statement of Jourdain, or a direct translation from other writings of the German.

its cardinal number 'Aleph-zero.' That Aleph-zero is a *transfinite* number, that is to say, is not equal to any finite number μ, follows from the simple fact that if to the aggregate $|\nu|$ is added a new element e_0, the union-aggregate $(|\nu|e_0)$ is equivalent to the original aggregate $|\nu|$. For we can think of this reciprocally univocal correspondence between them: to the element e_0 of the first corresponds the element 1 of the second, and to the element ν of the first corresponds the element $\nu+1$ of the other." Now $\nu =$ the totality of finite cardinal numbers. But "ω is *not* a maximum of the finite numbers, for there is no such thing." [23] Before this series with a totality but no maximum, have we not the right to hesitate, until we are in possession of a definition of "totality" that is, no matter how unsatisfactory in itself, not discordant with its having no maximum? But any definition involves a *petitio principii*. "The word *all*," writes Poincaré,[24] "has a very precise meaning when it is a question of a finite number of objects; but for it still to have a precise meaning when the number of objects is infinite, it is necessary that there should exist an actual infinity. Otherwise *all* these objects can not be conceived as existing prior to their definition, and then, if the definition of a notion N depends on *all* the objects A, it may be tainted with the vicious circle, if among the objects A there is one that can not be defined without bringing in the notion N itself." Consequently we fail to see how the argument given above is to mean anything at all to one who denies that a series may have a totality but no maximum, namely, to one who denies on this score the existence in actuality of a "completed" infinite.

The existence of "transfinite numbers" is demonstrated in the following manner:[25] "The formation of the finite real integers rests on the principle of the addition of a unit

[23] *Op. cit.*, Intro., p. 78.

[24] *Science and Method*, p. 195.

[25] Cantor, *op. cit.*, Intro., pp. 56-7.

to a number which has been already formed; Cantor calls this moment the *first principle of generation*. The enumeral of the number of the class (1) so formed is infinite, and there is no greatest among them [*sic*]. Thus, although it would be a contradiction to speak of the greatest number of the class (1), there is, on the other hand, nothing objectionable in imagining a *new* number ω, which is to express that the whole collection (1) is given by the law in its natural order of succession. By allowing further positings of unity to follow the positing of the number ω, we obtain with the help of the first principle of generation, the further numbers ω+1, ω+2, ..., ω+ν, ... Since here again we come to no greatest number we imagine a new one, which we may call 2ω, and which is to be the first which follows all the numbers ω and ω+ν hitherto formed." It should be observed that there is an avoidance of contradiction by the use of a meaningless ambiguity in stating, as above, that 2ω "is to be the first number which follows all the numbers . . . hitherto formed." Elsewhere[26] the sophism occurs in a rather more obvious form: "There is no contradiction involved in postulating a new non-finite number which is to be the *first after* all the finite numbers." Cantor himself will not, of course, nor will Jourdain let him, admit that the new "non-finite number" is to follow the greatest finite number. To avoid this recourse is had to the ambiguous phrase "first after *all* the finite numbers." Exactly what is this to mean? It has but one advantage that we can see: whereas "first after the greatest finite number" would be an honest, though suicidal phrase, the phrase chosen can mean nothing, exactly, and the contradiction, though less obvious, is apparently but speciously avoided. It remains the perilously loose cornerstone of a structure otherwise devoid of a foundation.

[26] *Ibid.*, Intro., p. 54.

"The logical function which has given us the numbers ω and 2ω," continues Jourdain,[27] "is obviously different from the first principle; Cantor calls it the *second principle of generation* of real integers, and defined[!] it more closely as follows: If there is defined any definite succession of real integers, of which there is no greatest, on the basis of this second principle a new number is created, which is defined as the next greatest number to them all[!]. . . . By the continued application of both principles we get successively, the numbers 3ω, $3\omega+1$, ..., $3\omega+\nu$, ..., $\mu\omega+\nu$, ..., ω^2, ..., *and so on indefinitely* [italics ours]." This, it must be remembered, is at the logical inception of Cantor's work. The inconsistency is apparently not noticed, when, subsequently, it is proved that $\omega+1=\omega$.[28] But if this latter statement is true, it necessarily invalidates the process by which "transfinite numbers" of higher orders are reached. In short, the process in question reduces itself to this: Abrogate the law of mathematical induction, and, Presto! we have a "transfinite number"; reinstate it, and we have an "infinite number" of "transfinite numbers" of order A; abrogate it, and, Presto! we have a "transfinite number" of order B; reinstate it, and we have an "infinite number" of "transfinite numbers" of order B; and so on without end. Comment upon the technique when it is stated thus openly seems needless. Cantor's hierarchy of "infinite numbers" gets him, of course, nowhere; and he seeks refuge in the familiar and impotent, though impudent, phrase "and so on." Yet he speaks unblushingly of the "totality of all the numbers formed by the help of the two principles," vainly attempting, it would seem, to escape by the door that Poincaré so effectively bolted.

[27] *Ibid.*, Intro., pp. 57-8.

[28] Cantor, *op. cit.*, p. 104; Russell, *Introduction to Mathematical Philosophy*, p. 86.

Another writer[29] has preferred to make his escape from this chamber of horrors through the chimney, as may be seen by the following excerpt: "He [the modern mathematician] starts from the aggregate, which he analyses into the Finite and the Infinite, and the latter he analyses into the Transfinite and the Absolute. . . . It is the Transfinite subdivision of the Infinite to which the idea of number is applicable, and which is, therefore, in a sense inseparable from the Finite. Infinite numbers or series ought then to be more correctly described as *Transfinite*. But the processes of mathematics do not end here; they reach up to the idea of the *Absolute Infinite*, the conception of which has been attained in recent years by mathematical work. . . . There are unending series of Alephs or infinite numbers as distinct from one another as I is from o . . . but can be reached in the same way by induction. . . . Broadly speaking, we may say that the raising of an Aleph to a power may make it transcend the Finite [as though it did not already!] and melt into the Absolute. There all mathematical processes which find their goal in the Absolute would find their annihilation there [*sic!*]. No finite mathematical conception [which irresistibly suggests that we shall soon possess infinite conceptions as well as conceptions of infinity] would be applicable to it."

Here, in a word, it would seem, mathematics must, for the moment, rest. Broadly speaking, we are nearly persuaded that something or other has almost found something analogous to annihilation somewhere. After an appreciable portion of time has passed over the bowed heads of awe-struck mathematicians, another stupendous intellect will happen again on this trick of abrogating the law of mathematical induction, defining a Third Principle of Generation, "creating" an Absolutely Absolute "Infinite

[29] E. F. Jourdain, *On the Theory of the Infinite in Modern Thought*, 1911, pp. 20-3.

Number," and then reinstating the outraged law to generate a new infinite series of infinitely "infinite numbers," "melting" when his fancy tires, into a new Absolute. But, we humbly ask, why not anticipate the glory of these future Cantors? Why not amaze the populace by defining an "infinite number" of Principles of Generation, and have done with it?

With but two such principles at his disposal, we marvel at the restraint of their inventor. Equipped with them, and with the precedent of "creating" new entities whenever needed, we should expect him to obtain an axiom from which the existence of God, the Immortality of the Soul, and, perhaps, the structure and function of the Holy Ghost, would follow as obvious corollaries.[30] Whereas most of us are content, in order to sate our passion for wonder, with the "ordinary" finite numbers, Cantor's self-control remains in operation until he is led on to speculate upon the upper ranges of his transfinities. Then his prose becomes tremulous and ecstatic, and, in such passages as the follow-

[30] It is almost unnecessary to remark that the above was written in a vein of extravagant satire. Hardly was the ink dry, however, when we discovered that the lamentable oversight, to which we directed attention above, has, for all practical purposes, been remedied. We take pleasure therefore in referring the morbidly curious among our readers to the *Hibbert Journal* for January and April, 1909, in which Cassius J. Keyser, Adrain Professor of Mathematics, Columbia University, deduces from the theory of "transfinite numbers," the solution of the antinomy of God's Omnipresence and man's freedom, the Doctrines of the Trinity and the Omnipresence. The Omnipresence follows nicely from the theory of the continuum; the antinomy in question disappears if one realizes that, from the infinite point of view, so to speak, the "dignity and power" of Omniscience are not lowered even if that part of experience which man controls has not been drawn into the sphere of Omniscience. As to the Trinity, let the even integers represent the Father, the odd integers the Son, and the fractions having integers for their terms, the Holy Ghost. *Ergo*, three in one and one in three, each distinct yet of the same substance, and each co-equal with each and with the whole. In introducing this occult tid-bit we stated that Cantor's oversight had *practically* been remedied. The term is used advisedly. For some reason, Professor Keyser has omitted the "infinite" number of incommensurable, irrational, imaginary, and transcendental numbers. We meddle in theological matters with considerable diffidence, but humbly suggest that these be the Devil.

ing, it is refreshingly borne in upon us that he is, after all, but clay: "The Absolute can only be recognized, but never apprehended. . . . The absolutely infinite sequence of numbers thus seems to me to be, in a certain sense, a suitable symbol of the Absolute; whereas the infinity . . . which has hitherto served for that purpose, appears to me as a vanishing nothing in comparison with the former. . . . The number γ stands, to the numbers of the number-class which has this power, in a magnitude-relation whose smallness mocks all description. . . ." Elsewhere he justifies the concepts of pure mathematics by deduction from "the unity of the All, to which we ourselves belong."[31] We had no idea that bad philosophy could throw so bright a light on the genesis of mathematical concepts! And we now know that Cantor was driven to transfinities by not only a logical need but a spiritual hunger.

All this, of course, is familiar. Our readers as well as we, it may be hoped, have learned to avoid this particular metaphysical quagmire. Newton, despite his addled theism, after all kept his mathematics decently removed from his theology; and although Whately was an archbishop and Berkeley a bishop, the sacerdotal yearning of neither was allowed to contaminate at the very source the principles of the profane sciences which they courted. Were it not for Cantor's prestige today, his attempt to keep butter and cheese in the same ice-box would deserve no more critical attention, in fact, than that accorded astronomical divines who debauch their emotional natures with panegyrics on the vastness of the stellar universe. For a closer examination of Cantor's doctrine reveals, as such ontological utterances immediately suggest, only a tangled web of increasingly contradictory dogmas. In one place[32] it is stated that the "nature of this new kind of number is de-

[31] Cantor, *op. cit.*, Intro., pp. 62-3, 67 (direct quotations).
[32] *Ibid.*, Intro., p. 74 (direct quotation).

pendent on the nature of *things* [italics ours] and is an object of investigation." Elsewhere,[33] this realism is abandoned for phenomenalistic positivism: "There is no danger to be feared for science from this freedom in the formation of numbers, for . . . every mathematical conception has in itself the necessary corrective—if it is unfruitful or inconvenient it . . . is abandoned." No attempt is made to reconcile these assertions, although one would think that with so transcendental a technique, little difficulty would be experienced in so doing. If one accepts the realism of the first passage, what can be said in extenuation of the second? If, on the other hand, one accepts the positivism of the second passage, have not these transfinities amply demonstrated their unfruitfulness and inconvenience, in that their only positive effect has been to entangle powerful mathematicians in a web of paralogism, and drive lesser men into Korzybskian absurdities?

"It was," writes Hobson,[34] "recognized by Cantor[35] that the collection of elements into an aggregate is only valid provided a conception free from contradiction is the result." This frank statement on the part of Cantor would appear to strangle the theory of transfinite numbers at its birth. It may be noted in passing that this particular point in mathematico-obstetrics, by which Cantor himself would appear to impugn the viability of his offspring, has raised a considerable literature. A guide-book to this philosophical desert of words in the exploration of which one can spend much time with little profit, is afforded by Hobson (*op. cit.*, Vol. I, pp. 236ff.).

Dangerous as we must deem such flights of unpiloted fancy, when our leading mathematicians are persuaded to take passage with men whose logic has not the sobriety of a prelate's, flat misstatements of fact are more reprehen-

[33] *Ibid.*, Intro., p. 68.

[34] *Op. cit.*, Vol. I, p. 237.

[35] P. E. B. Jourdain, *Philosophical Magazine* (6), Vol. VII, p. 55.

sible, if that is possible, than speculations of the order just examined. And Cantor is guilty of the graver error. "ω," he writes,[38] "may be regarded as the limit towards which the variable ν tends. Here ω is the least transfinite cardinal number which is greater than *all* the finite numbers; exactly in the same way that $\sqrt{2}$ is the limit of certain variable increasing rational numbers, with this difference: the difference between $\sqrt{2}$ and these approximating fractions becomes as small as we wish, *whereas* ω—ν *is always equal to* ω."

Now, when a scientist directly states that certain evidence supports his contention, it is customarily assumed to be the truth, and the statement, if not obvious and immediately verifiable, passes unchallenged. Acquaintance with Cantor's logic has, however, taught us to be wary of his asseverations. In truth, upon submitting the claim advanced above to a casual scrutiny, it is found to be grossly misleading. *For, that a series of fractions can be found to approximate to* $\sqrt{2}$ *as closely as we wish* (i. e., *so closely that the upper term of the series and* $\sqrt{2}$ *are, for our purpose, indistinguishable*) *is the very circumstance which allows us to regard* $\sqrt{2}$ *as a definite and completed quantity.* We ignore for the present the additional, but for our purpose irrelevant, circumstance that it is possible to give a geometrical interpretation to $\sqrt{2}$. Cantor makes no attempt to cope with the difficulty above pointed out, but to avoid its consideration, employs the amazing prevarication just noted. The failure of the analogy between the series of fractions and $\sqrt{2}$ with the series of finite cardinal numbers and ω (ω—ν always equalling ω) destroys utterly the logical basis upon which rests the "definiteness" and "completeness" of transfinite numbers.

[38] Cantor, *op. cit.*, Intro., p. 77 (direct quotation).

V

A rigorous definition of *number*, the empirical origin of which concept has already been touched on, is obviously of fundamental importance to mathematical logic. Number (in general) is defined by Mr. Russell as "anything which is the number of some class." [37] He maintains, justly we believe, that such a definition is only apparently circular, since "the number of a given class" (number in particular) has been defined previously without the use of the notion of number in general, thus: "The number of a class is the class of all classes that are similar to it." [38] Unfortunately, in this definition of number in particular, he has used phrases which denote particular numbers, *i. e.*, "one class," "the class" [1], and "all the classes" [how many we know not, but assuredly some particular number]. Number in particular is thus defined by reference to particular numbers. This circularity, we regret to say, is actual. Almost any mathematician, bent on defining number might do no worse than this; it remained for a logician to involve himself in the following tangle, which a closer scrutiny of the word *similarity* lays bare. Remembering that we are in the process of defining number (in particular), let us examine Mr. Russell's definition of that word: "One [1] class is said to be 'similar' to another [*one* (1)] when there is a one-one [1 1] relation [*all relations, of course, relate two* (2) *relata*] of which the one [1] class is the domain while the other [*one* (1)] is the converse domain." [39] Now *domain* is defined as "the [*one* (1)] class of those terms [*an undetermined particular number*] that have a [*one* (1)] given relation [*relating, as before, two* (2) *relata*] to something [*some one* (1) *thing*] or other [*some one* (1)

[37] *Introduction to Mathematical Philosophy*, p. 19.
[38] *Ibid.*, p. 18.

other thing]." [40] All these definitions are subsumed implicitly in the use of the word "similar" in the definition of number just given. Mr. Russell, instead of involving himself in one *petitio principii,* has hence succeeded in entangling himself in twelve. "The fact is," as Poincaré writes,[41] "that it is impossible to give a definition without enunciating a phrase, and difficult to enunciate a phrase without putting in a name of number, or at least the word several, or at least a word in the plural. Then the slope becomes slippery. . . ." It has apparently proved too slippery for Mr. Russell, although he can console himself with the reflection that the base of the slope, like Dante's Limbo, is peopled with august spirits.

With Frege's definition,[42] virtually identical with the definition of Mr. Russell, we have no immediate fault to find, since with most of its many logical vices and its peculiar logical virtues, our argument, at present, is not involved.[43] But with that virtue, or rather vice, which most endears it to the apologists of the infinite, it is otherwise. The definition, as Frege himself remarked, does not appear to exclude "infinite numbers." For if two infinite classes can be shown to be similar they must, perforce, have the same "number." A clear and well-defined conception of *similarity* is therefore an immediate requirement. Mr. Russell[44] defines similarity as follows: "Two classes are said to be similar when there is a one-one relation which

[39] *Ibid.,* p. 16.

[40] *Ibid.,* p. 16.

[41] *Science and Method,* p. 155.

[42] *Grundgesetze der Arithmetik,* Vol. I, 1893.

[43] With respect to the relative merits of Peano's and Frege's definitions, it is perhaps sufficient to note that both involve the concept *class,* a notion in need of fully as much logical simplification as that of *number.* That Mr. Russell's reasons for preferring Frege's definition to Peano's are not clear, or at any rate not convincing, has been remarked by S. Waterloo (Aristotelian Society, *Proceedings,* N. S., Vol. X, pp. 144-9) although he makes no attempt to cope with, or indeed note, the circular argument above examined.

[44] *Introduction to Mathematical Philosophy,* pp. 15-6.

correlates the terms of the one class each with one term of the other." He thereupon shows, in the usual fashion, that if "all" the natural numbers are written down as below, a one-one correlation can be made between the numbers in both rows:

1	2	3	4	5	6	7	8	9	10 etc.
2	4	6	8	10	12	14	16	18	20 etc.

Beneath each number in the upper row occurs its double, and there will be as many numbers in the lower as in the upper row. Therefore the number of "all the numbers" and the number of "all the even numbers" is the same, namely ω, although in one case the odd numbers are left out of the reckoning. Thus $\omega+1$, $\omega+2$, $\omega/2$, $2\times\omega$, and so on, all equal ω: the peculiar properties of "infinite numbers." It is interesting and instructive to note, at this point, that those consequences of the theory of transfinite numbers which are of actual value to mathematics appear to be the negative consequences, namely, those asserting that certain processes can not be applied to the infinite. A beautiful example of this solitary virtue amongst an infinity of vices is afforded by the refutation of Bertrand's "proof" of the Parallel Postulate, a "proof" that, it will be remembered, deceived even De Morgan.

At the root of this, of course, there lies a subtle fallacy, namely, *that two "infinite classes" can be proved similar.* A direct demonstration of this similarity, naturally, is never given, since this would require an eternity, if not longer. Mr. Russell, for example, contents himself with "pointing out" this and that, as indicated above, and with apagogic proofs which can have little value until the theory of classes is far more thoroughly explored. C. J. Keyser,[45] however, goes further than this, stating that "we can set up a one-to-one correspondence between the integers of the entire class of integers, and the integers comprising a part

[45] *Mathematical Philosophy*, 1922, p. 301.

. . . of the entire class . . . which is what any fool can see." The proof of an abstruse theorem first enunciated in the nineteenth century and amounting, in fact, to a denial of the axiom that the whole is greater than the part, by dividing men into Fools and Not-fools, seems to us fairly lacking in rigor. One is irresistibly reminded of the Hindu geometer, who, when called upon to demonstrate apodictically a theorem, the truth of which seemed obvious upon visual inspection but difficult to prove, made the required construction in the sand, and, raising his hands, cried, "Behold!" [46]

About "infinite numbers," in fact, it appears to be nearly as easy to say one thing as another, on condition that the demonstration does not attempt the logical rigor we have shown to be necessary. For example, take again the two rows of numbers and, instead of relating each number in the upper row with that beneath it, let us relate each number in the lower row with its *duplicate* above, thus:

1	2	3	4	5	6	7	8	9	10	etc.
	2		4		6		8		10	etc.

Now, each number which occurs in the lower row must, when "all the numbers" are considered, occur in the upper as well. *Consequently, each number in the lower row will be related to its mate in the upper row, and the odd numbers in the upper row will remain unrelated. A one-one correlation between the two classes can not be effected, in other words, and therefore the two classes are not similar.*

[46] Hasdai Crescas, one of the most brilliant of Jewish thinkers, appears to have been one of the first to recognize the meaninglessness of speaking of the equality or nequality of infinite classes. A recent historian has summarized his arguments as follows: "Crescas remarks (that) it is not exact to say that one infinity cannot be greater than another, the fact is that it cannot also equal another. Not only inequality but also equality, is inapplicable to infinities. For even when we say that a thing equals, we have in mind a whole quantum, in other words, a limited notion. . . . All mathematical considerations, all signs of equality and inequality, must be dropped entirely, if we really wish to conceive the endless." (*The Problem of Space in Jewish Mediaeval Philosophy*, by I. I. Efros, 1917, pp. 105-6.)

This fantastic consequence, neither more nor less fallacious than all others concerning the "completed infinite," though reached by logic howsoever fine, is certainly not more flimsy than the tissue of sophisms worked on those vicious circles that were the embroidery-hoops of Georg Cantor; and it is, so to speak, infinitely more in accord with common reason.

It is interesting in this connection to recall the wordy war waged over the theorem advanced by Zermelo[47] to the effect that every class can be well-ordered, *i. e.*, can be arranged in a series in which every sub-class (except, of course, the null-class) has a first term. Imagine, says Mr. Russell,[48] a millionaire who had such a passion for buying boots and socks that he ultimately acquired Aleph-zero pairs of each. How many single boots had he, and how many single socks? One would naturally suppose that, since two times Aleph-zero equals Aleph-zero, he would have Aleph-zero boots and Aleph-zero socks. But, Mr. Russell observes, in order to prove that an aggregate has Aleph-zero terms, it is necessary to arrange them in a progression. With the boots this is simple, since we make, once for all, an arbitrary selection; for example, we take the left boot first and the right boot second. But when we come to socks, Mr. Russell sees with dismay that the manufacturer has made left and right socks indistinguishable. In order to arrange them in a progression, therefore, the arbitrary act of choice must be made anew with each pair. And an infinite number of arbitrary acts of choice is, Mr. Russell observes, an impossibility. Hence the problem.

Not the least paradoxical of the apparently infinite num-

[47] *Math. Annalen*, Vol. LXV, p. 110. For a more precise statement of Zermelo's Axiom, the Multiplicative Axiom, or General Principle of Selection, as it is variously called, and for a partial enumeration of its Protean forms, *vide supra*, and Russell, *Introduction to Mathematical Philosophy*, pp. 117-30; Hobson, *The Theory of Functions of a Real Variable*, Vol. I, pp. 248ff.

[48] *Introduction to Mathematical Philosophy*, pp. 125-7.

ber of paradoxes relating to the mathematical infinite, is the fact that on some questions (*e. g.*, the existence of the infinitesimal, the question of the socks, and there are others) Mr. Russell's logic works with devastating precision, whilst upon other questions he commits in but slightly different shape the very fallacy against which elsewhere he has declaimed eloquently. The problem of the socks is exactly analogous with the problem of proving two "infinite classes" to be similar by effecting a one-one relation between their members. An "infinite number" of arbitrary acts of choice is, as Mr. Russell points out, an impossibility. So also, we submit, is an "infinite number" of arbitrarily effected relations between the terms of two classes with an "infinite number" of terms. To prove the similarity we must show the one-one correspondence between each and every term, *since the law of mathematical induction* ($n+1$ will possess every hereditary property possessed by n) *is inapplicable to infinite collections.* This involves an "infinite number" of arbitrary acts: 1 is related with 2, 2 is related with 4, 3 is related with 6, and so on. And an "infinite number" of arbitrary acts is assuredly—and admittedly—an impossibility. Zermelo's Axiom, like the Parallel Postulate, is true for finite quantities. Only in applying these undoubted axioms "indispensable and undemonstrable" as Poincaré has said, to the "completed infinite" do contradiction and difficulty arise.

In every case in which the similarity of "infinite classes" is considered, we meet with some process similar to those examined. As it is obviously impossible to write "all the numbers" would exhibit the same one-one correspondence. induction is assumed to do the rest—to show that "all the numbers" would show the same one-one correspondence. *But this very law of mathematical induction is admittedly inapplicable to "infinite numbers"—its failure is one of their most conspicuous attributes, and this very failure is*

often used to define them.[49] *With the admitted failure of mathematical induction to apply to "infinite classes," all hope of proving two such classes to be similar, vanishes. For if no two "infinite classes" can be proved similar, they can not have a number, for the number of a class is the class of all classes that are similar to it.*

VI

Arguments furnished by the defenders of infinity could be almost interminably multiplied. Additional evidence on either side, however, would do little but delay an indictment which, in view of the formal defence above offered, points to the justice of an immediate conviction. We may hence remark at this point that the doctrine of infinity (save as it be interpreted to mean that a *process* can by definition be repeated) is as repugnant to the principles of logic as it is to every datum of experience. Its defence can no more justly be pleaded on dialectic grounds, by him who keeps faith with his premisses, than it can be on experiential grounds, by him who consistently honors his senses.

Upon the philosophic doctrine of necessity it would, of course, be impertinent for us to enter in this inquiry. There is, however, so strange a likeness between believers in free-will and believers in "infinite numbers," that we can not forbear briefly pointing to it. Between the libertarians who maintain (albeit with more subtlety) that they can desire what they actually do not wish for, and the infinitists who maintain (albeit not so candidly) that they can crave a number they are powerless to think of, there is a strong family resemblance, at least in the heat of such appetites. One, we hold, is an absurd piece of illogical reasoning; the other, a logical absurdity. Though some writers may feel able to draw a nice distinction between these epithets, we

[49] *Cf. ibid.*, pp. 78ff.; *Our Knowledge of the External World*, pp. 195ff.

ourselves are not competent for the essay. We are satisfied with having merely drawn the comparison itself, perhaps not the least virtue of which comparison is that heretofore (so far as we know) none has drawn it.

That neither Cantor nor Mr. Russell has brought forward all that might be and has been advanced in support of the theory of infinite aggregates will, of course, be clear to any one whose historical perspective affords a view, broader than that here developed, of the thesis common to them and their predecessors. Many thinkers have dedicated their highest talents in attempts to render the concept of the infinite reasonable. In no era of thought has the problem been neglected. The natural consequence of such interest is that a very considerable literature has grown up around it—much of it serving as a kind of defensive barricade, though some of it taking the form, rather, of a besieging manoeuvre whereby infinity, so to speak, was to be starved out and thus reduced to submission.

Historically this long battle is interesting. But if it has enlisted the attention of minds superior in some respects to those just examined, we still can find no points of superiority in earlier writers which are not amply balanced in their followers by the advantages these latter possess in succeeding them.[50] It is on this account that we are persuaded of the legitimacy, to say nothing of the convenience, of examining the problem as we have so far chiefly done: first through an analysis of the arguments of one of our most eminent contemporaries, and then through a first-hand inspection of those "proofs," which, after accepting them from another, he has proclaimed as being, not merely the most sophisticated and exhaustive procurable, but as proofs intolerant of question. It will thus be seen that our strictures, though aimed immediately at Cantor and Mr. Russell, are really directed through them at their col-

leagues, whether of this or of an earlier generation. And whilst we have regretted the necessity of assaulting two otherwise unusual thinkers, we can not but feel glad that through their eminence in the field of mathematical logic due attention may be drawn to that dark corner of it wherein both so noisily have stumbled.

[50] According to Florian Cajori (*A History of Mathematics*, 1919, p. 67), "Origen's arguments against the actually infinite have been pronounced by Georg Cantor the profoundest ever advanced against the actually infinite." From this it might be, albeit incorrectly, deduced that Cantor had never examined the founders of British empiricism, or even Aristotle. *Cf.* Origen, *De Principiis*, Bk. III, Chap. 5, for an example of what Cantor calls profundity.

NOTE

Mr. Russell, it is interesting to note, did not accept the "axiom of infinity" without a mild protest on his part, or a canny realization that his reader's "robust sense of reality" might rebel at the fiction he is bidden to swallow. He candidly, if unnecessarily, warns his reader that "the first thing to observe is that there is an air of hocus-pocus about it; something reminds one of the conjuror who brings things out of the hat. The man who has lent his hat is quite sure there wasn't a rabbit in it before, but he is at a loss to say how the rabbit got there." (*Introduction to Mathematical Philosophy*, p. 135). But Mr. Russell's own incredulity, if creditable, seemingly was short-lived; and he now appears as confident of the collapse of his disciples' doubts as he is certain that his own have been legitimately buried. Their *coup de grace* in his own case, he confesses was received some twenty years ago upon his realizing that the doctrine he then defended (*i. e.*, that the class of all enumerable objects "must, if there be such a class, have a cardinal number which is the greatest possible") openly clashed with Cantor's doctrine that "there is no greatest cardinal." "When I first came upon this contradiction, in the year 1901," he continues, "I attempted to discover some flaw in Cantor's proof that there is no greatest cardinal. . . . Applying this proof to the supposed class of all imaginable objects, I was led to a new and simpler contradiction. . . ." What was this contradiction that had simplicity and novelty to boot? Simply that "if there is such a thing as 'everything' then 'everything' is something, and is itself a member of the class 'everything'." But a deadly alternative hereupon follows. If some classes are not members of themselves, these in turn become a class. Is this new class a class which embraces itself or not? "If it is, it is one of those classes that are not members of themselves. . . . If it is not, it is not

one of those classes that are not members of themselves." In other words, it *is* a member of itself. Both hypotheses thus imply their contradictories. "This," Mr. Russell aptly concludes, "is a contradiction." (The foregoing, known as the Burali-Forti contradiction, is examined in Mr. Russell's *magnum opus*, *Principia Mathematica*, a prodigious work painstakingly performed in collaboration with Mr. A. N. Whitehead who, it may be added, commits himself therein to a belief in an "infinite number."

Now all this is extrinsically very interesting, but we really can not understand why a logician should lead his reader through such a maze of difficulties as those surrounding the "theory of types" when he has already admitted that "much of this theory is inchoate, confused and obscure," and that it "does not belong to the finished and certain part of our subject." Indeed the very contradiction Mr. Russell develops, is, by his own admission, meaningless; it is created by a "mixture of types." We therefore can only suspect that logical confidence is partially wanting in the writer.

We perhaps should add, lest our attitude be misconstrued, that Mr. Russell can not be accused of deliberately misleading his reader; we are convinced of his painstaking honesty. But one of his commendable and conspicuous characteristics, a willingness to change his mind upon the instant of suspecting himself to be in error, not infrequently renders him unduly indulgent, it seems, toward the logical claims of the improbable. He appears to be just a trifle too fascinated by the attractions of paradox and antinomy. Logical difficulties are therefore sometimes recounted at great length, for the sheer delight they confessedly afford him; in his eyes the problem itself often looks very much more interesting than its solution. We comment on this characteristic because, from the point of view of persuasion, it seems unfair to those of Mr. Russell's arguments which are really significant; it certainly is prejudicial in the eyes of those who, less captivated by the bizarre than he is, are less hospitable towards such funambulisms of the intellect.

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